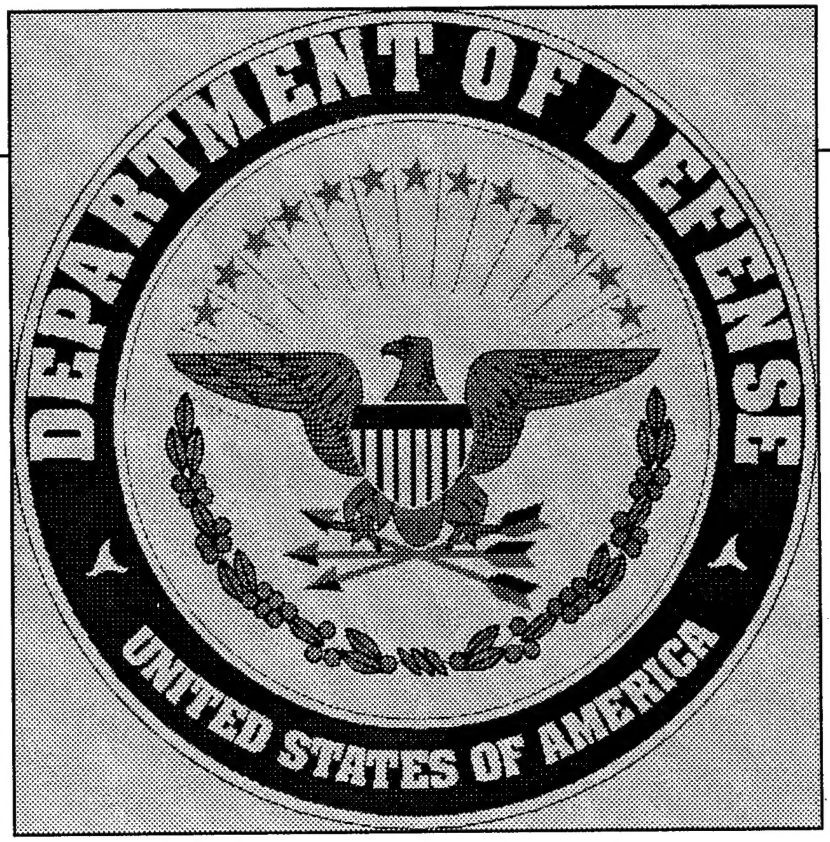

CAIS STANDARD MANUAL

SYSTEM NO. 15
DAMS

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CAS PROJECT
CAIS MANUAL

Issued April 28, 1995

8 Mar 96

MEMORANDUM FOR DTIC-OCP
ATTN: Ms. Lue Lynch
8725 John J. Kingman Road, Suite 0944
Fort Belvoir, VA 22060-6218

FROM: AL/EQ (STINFO)
139 Barnes Drive. Suite 2
Tyndall AFB FL 32403-5323

SUBJECT: Transmision of Technical Documents

1. As per telephone conversation with Andrew Poulis, EQ/TIC, the attached CAIS CTDS manuals are forwarded for accession, cataloging, and microconversions. Please forward the accession numbers to:

Andrew Poulis
AL/EQ/TIC
139 Barnes Drive. Suite 2
Tyndall AFB, FL 32403-5323

2. The Distribution statement should read as follows: Approved for Public Release: Distribution Unlimited.

3. If you have questions about these documents, please contact Andrew Poulis at DSN 523-6285.

Larry L. Testerman
LARRY L. TESTERMAN
Scientific and Technical
Information Program Manager

Atchs: Manuals

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ABSTRACT

GENERAL ORGANIZATION

At this installation the list of facilities to be surveyed, including infrastructure, will be addressed on the basis of 32 unique systems that form the CAIS Engineering Deficiency Standards and Inspection Methods document. Each system deals with a specific technical aspect of the facility to be surveyed. Within each system a further breakdown is made to subsystems, each having a related list of components. Detailed observations of the listed defects are provided so as to allow the entry of observed quantification data. A DOD CAIS manual is provided for each of the 32 systems with an internal organization as outlined below:

INSPECTOR'S GUIDE

I. General
   - A. Level I Inspection Method Description
   - B. Level II Inspection Method Description
   - C. Level III Inspection Method Description

II. General Inspection
   - A. Process. This section describes the process of the inspection activity and work to be completed prior to the start of the field inspection.
   - B. Location. This section describes the procedure for locating the inspection units in the facility or infrastructure on this installation.

III. Inspector Qualifications
   This section notes the minimum qualifications for the person or persons performing the survey.

IV. Inspector Unit
   This section describes how the IU (Inspection Unit) is determined for the particular component being surveyed.

V. Unit Costs
   This section notes the nature of repair costs for this system.

VI. Standard Safety Requirements
   This section lists safety procedures and equipment required to implement a safe environment for the conduct of this survey.

VII. Standard Tools
   This section lists a set of standard tools required for the general conduct of this survey.

VIII. Special Tools and Equipment Requirements
   This section refers to special tools or equipment requirements endemic to the nature of the system being surveyed.

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IX. Level II Inspection Method Keys

This section explains the use of keys as they relate to Level II Guide Sheets.

X. Level III Inspection Method Keys

This section explains the use of keys as they relate to Level III Guide Sheets.

XI. Replacement Cost

This section describes the nature and location of replacement cost data.

XII. Appendices

Appendix A. Provides a listing and definition of all abbreviations used both in the Standards and in the data base.

Appendix B. Provides a glossary of terms with their definitions as used in the Standard.

Appendix C. This section contains a listing of the average life cycle durations for each assembly* in the Standard.

* Assembly is a term describing the level at which replacement rather than repair occurs. This can be at the subsystem or component designation, depending on the system being surveyed.

SYSTEM TREE

The System Tree is a graphical representation of the Work Breakdown Structure, showing system, subsystem and component relationships for the Dams System.

INSPECTION METHODS

Description

Describes the nature of what is to be condition surveyed.

Special Tool and Equipment Requirements

Lists any special tools required for this specific subsystem.

Special Safety Requirements

This section outlines any special safety measures or equipment required for this specific subsystem so as to maintain a safe environment and process in the conduct of the condition survey.

Component List

All components to be surveyed under this subsystem are listed here.

Related Subsystems

All other subsystems that have a survey relationship to this subsystem are listed here to help coordinate a complete and thorough condition assessment survey.

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Standard Inspection Procedure

This statement indicates the various levels of survey effort required for this subsystem.

Components

The previously listed components of this subsystem are described with a survey procedure recommended on a component by component basis. For each component there is a listing of defects with each defect broken down into observations describing the nature and severity of the defective condition observed. The surveyor enters a quantification value for each defect/observation encountered in the field CAIS device (DCD) to record the result of his survey.

References

This page lists the reference sources from which the foregoing subsystem data was developed.

Guide Sheet Control Number

This section lists the key numbers that tie the written Level II and Level III guide sheets to specific components in this subsystem.

Level II and Level III Inspection Method Guide Sheets

This section contains the detailed descriptions of the Level II and III survey and inspection procedures for this subsystem.

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INSPECTOR'S GUIDE

I. GENERAL

A. Level I Inspection Method

The purpose of the Level I Inspection Method is to detect observable defects in the dam, reservoir, and other related facilities. A dam is an active structure, subject to erosion, corrosion, and deterioration by wind, water, ice and temperature. A well documented inspection will observe this deterioration and identify needed repairs that, if carried out, can prevent structural failure and provide full life cycle usage of the dam.

The Level I Inspection Method for embankment or concrete dams consists of an inspection of the readily accessible parts of the dam and appurtenant works as described in the work breakdown structure. The Level I Inspection Method is a walk-by inspection while taking measurements. The standard inspection is designed to be performed by one inspector, although entrance into any internal structures or inspection of steep slopes will require a minimum team of two inspectors.

If design or as-built drawings of the dam are not reviewed prior to the inspection, then a second inspector will be required during the Level I inspection to assist in obtaining measurements of the various components and defects, and establishing station markers for identifying location along the dam structure.

The observations recorded by the inspector during a Level I inspection are designed to create a historical data base for the continued design life of the structure, to highlight particular items which require inspection by a qualified engineer experienced in the design and construction of embankment or concrete dams (whichever is appropriate), and to devise maintenance and repair strategy.

B. Level II Inspection Method

A Level II Inspection Method is performed to obtain additional information or measurements concerning a defect observed during the course of the Level I inspection process. In all instances, the Level II Inspection Method is additional work performed by the inspection personnel during performance of the Level I inspection.

C. Level III Inspection Method

Level III inspections should be conducted by an engineer or team of engineers experienced in the design and construction of embankment or concrete dams and should include a thorough systematic evaluation of the condition triggering the Level III inspection and an assessment of the safety and stability of the dam and its appurtenant works.

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Level III inspections should be performed when triggered by conditions observed during a Level I or Level II inspection or on a regularly scheduled basis, whichever occurs first (see Facility Manager Guide). In addition, Level III inspections should also be performed where inspection of appurtenant work components require difficult access methods to be used or when work to be performed by others is required prior to gaining access for the inspection.

Depending on the assessment of the potential impact of observed conditions on the safety or stability of the dam, advanced test and inspection methods may be required as part of the Level III inspection to determine the cause and/or extent of an observed defect.

II. GENERAL INSPECTION

A. Process

The Level I inspection shall be carried out for each component listed in the Work Breakdown Structure (WBS) for an embankment or concrete dam, where applicable. Potential defects have been identified along with relevant observations, allowing the inspector to prepare a record of observable conditions at the project site. The inspector will identify the defect, record the observation, and take measurements as necessary to record the quantity or extent of the defect. No attempt will be made to officially assess the safety of the dam or appurtenant works during this inspection. The observation of certain defects will automatically trigger a Level III inspection to be performed in order to confirm the severity of the observed defect and to assess the safety of the dam.

Prior to the start of a Level I inspection, the survey planners will obtain existing design or as-built drawings of the dam and appurtenant works for use in preparing for the upcoming inspection. This preparatory work will include becoming familiarized with the layout, geometric configuration, and dimensions of the dam as well as calculating lengths, surface areas, cross sectional areas, volumes and the actual number of specific items to be surveyed and which are required to complete the "Total Quantity Inspected" prompt in the Field CAIS program (see Form 15-B).

Level I and Level II inspections are to be performed with one or more personnel accompanying the inspector at the project site as specifically recommended in these documents.

B. Location

Level I and II inspections will be located by the inspector through a discrete entry into the Data Collection Device. The "IU" or component location will be derived from Facility-supplied segment numbering lists, maps or other I.D. numbering systems. For building associated "IU's" and components the Facility shall furnish plans annotated with room number schedules. In the case of non-room associated components, plans will be orientated with the top of each sheet being the north direction, so as to allow directional location and description. In the case where no maps or plans are available, the inspector shall enter a brief (65 character) description of location.

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III. INSPECTOR QUALIFICATIONS

The personnel performing standard inspections of embankment dams should have a minimum of 5 years experience in inspection of embankment dams and/or levees. The personnel performing Level I and Level II inspections of concrete dams should have a minimum of 5 years experience in inspecting concrete dams. In addition, the inspector(s) must be experienced in the observation and identification of slope stability issues. Inspectors will be specifically trained in the CAS system and its usage, and will be CAS certified.

IV. INSPECTION UNIT (IU)

Inspection of an embankment or concrete dam structure and its appurtenant works are generally performed at the same time. The IU is normally defined as the entire component inspected: the unit of measure (UOM) for embankments is SF (for the entire embankment surface); UOM for intake/outlet works is LF; UOM for spillway and emergency spillway is LF (for length of spillway, starting from crest to downstream edge); UOM for abutment is LF (length along intersection of dam and existing ground); UOM for downstream channel is LF; UOM for the reservoir is acre-foot; and UOM for any power structure is SF.

The DS/IM for Dams has been prepared using the assumption that the IU for each of the above listed components is the entire inspected component. Components can not be arbitrarily divided up in the field by the field inspector to make it easier to identify location of a defect. Identification of defect locations is handled through data input in the "Comments" screen. Selection of arbitrary IU's will yield inconsistent results which are detrimental to the cost estimating processes in Site CAIS.

The "Total Quantity Inspected" prompt while recording quantities inspected in the Data Collection Device is not necessarily the same as the IU quantity. The "Total Quantity Inspected" density input should be equal to the total size or quantity of component or object being surveyed for an observation within a particular component. Therefore, the "Total Quantity Measured" within an IU will vary depending on the unit of measure for that particular observation as designated in the DS/IM.

V. UNIT COSTS

The unit costs that are applied to the quantities recorded for each observation are contained within the site CAIS as component repair cost.

VI. STANDARD SAFETY REQUIREMENTS

Prior to inspection of the dam, the authority (Facility Manager) having jurisdiction shall be notified to secure proper access, safety briefings, and personal safety items. See Master Safety Plan for additional requirements.

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VII. STANDARD TOOLS

Employee Identification Card - to be worn or carried during all inspections
Data Collection Device (DCD)
Battery pack for DCD
100 ft tape measure
Folding Rule: 6 ft long (marked in inches or feet)
Binoculars
Flashlight
Hand Odometer
Keel, flagging or spray paint to be used to mark stationing during inspection.

VIII. SPECIAL TOOLS AND EQUIPMENT REQUIREMENTS

At the subsystem level, there are no special tools required for the Level I inspection of the associated components.

The use of a 35 mm camera is recommended during the Level I inspection to provide photo documentation of existing conditions of the dam structure and appurtenant works at the time of the inspection.

For some dam configurations, it may be necessary to use a ladder to gain access to spillway chutes or spillway control structure aprons and crests, particularly if the downstream end of the chute or stilling basin is underwater.

If available, and inspection of a given dam site warrants, a boat with life preservers and vests can be used as required to observe the upstream slope or face of the dam or intake works.

Level III Guide Sheets will address additional tools and equipment requirements that are specific to that particular method. Inspectors should review these sections in order to determine any special tool requirements for components they are to inspect.

IX. LEVEL II INSPECTION METHOD KEYS

Certain defect observations or the designated inspection of the operation of certain components will trigger a Level II test or inspection. The Facility Manager will be able to identify defects where a Level II test or inspection is flagged. The Level II key at the observation level will refer to a specific guide sheet.

X. LEVEL III INSPECTION METHOD KEYS

Certain observations will trigger a Level III inspection. The Level III key at the observation level will refer to a specific guide sheet. The Facility Manager will be able to identify deficiencies where a Level III inspection is flagged. These guide sheets, in many cases, will identify the Level III inspection and may refer the Facility Manager to a more sophisticated and costly test for consideration.

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XI. REPLACEMENT COST

A replacement cost for each subsystem type will be contained within the cost estimating system in the Site CAIS. Remedial measure costs to correct observed defects will be estimated by the engineer(s) subsequent to the results of a Level III inspection.

XII. APPENDICES

Appendix A - Abbreviations

A summary and definition of all abbreviations used in this system are contained in Appendix A which is located at the end of Dams.

Appendix B - Glossary

A glossary of terms used in this system are contained in Appendix B which is located at the end of Dams.

Appendix C - Life Cycles

A listing of the average life cycle durations for each assembly* in the Standard.

Note - Facility Manager's Guide

The following are included in the Facility Manager's Guide:

A table showing the required manhours to perform the standard inspection for this facility listed by Cat Code (three digit).

A listing of all Level III inspections with their estimated cost and time to perform. This list will include frequency of inspection for time driven Level III's.

* Assembly is a term describing the level at which replacement rather than repair occurs. This can be at the subsystem or component designation, depending on the system being surveyed.

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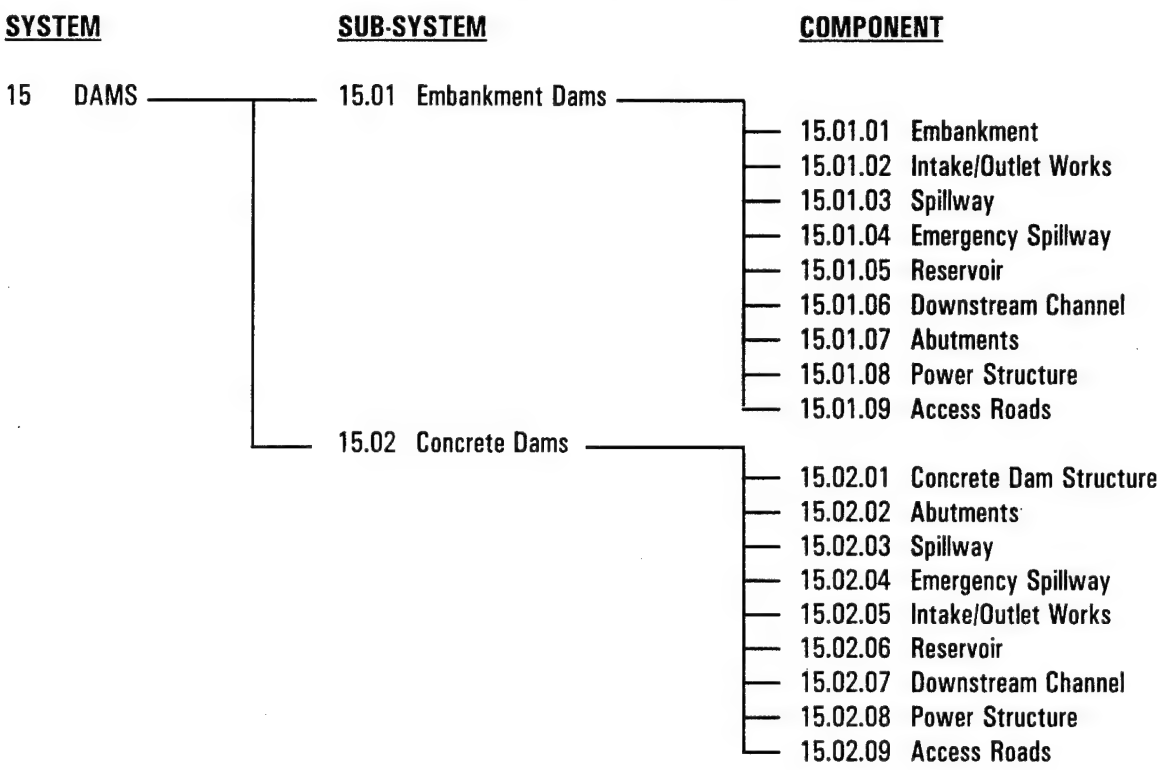
Figure 15-A. WORK BREAKDOWN STRUCTURE



15.01 EMBANKMENT DAMS

DESCRIPTION

Embankment dams are generally classified into two primary categories; earth and rock-fill. The two classifications are differentiated by the predominant fill material used during construction of the embankment.

Earth dams are constructed of suitable soils obtained from borrow sites or from necessary site excavations at the project site which are compacted in layers by mechanical methods. Upon completion of foundation preparation work, the earth fill materials are transported to the site, dumped and spread in layers of required thickness. The layers of soil are then compacted to specifications and the sequence of fill placement and compaction is continued until the embankment is constructed to the designed slope gradients and crest elevation. Earthfill dams can be classified into two main categories: homogeneous and zoned. Depending on available soil materials, the earth dam can be constructed of relatively homogeneous material or can be divided into zones of materials having different strength -deformation and hydraulic characteristics.

A rockfill dam is constructed of rock, either dumped in lifts or compacted in layers, in conjunction with an impervious layer. The impervious layer is used as a water barrier and can be placed either within the embankment as an earthen core, or on the upstream embankment slope. Materials which can be used for the impervious layer include earth, concrete, steel, asphaltic concrete, and wood. Rockfill dams can be classified into three groups, depending on the location of the impervious layer: 1. central core; 2. sloping core, or 3. upstream membrane. Central and sloping cores are usually constructed of earth fill materials, and construction of these types of rockfill dams require the use of transition or filter zones between the core and the outer rock shells. The upstream impervious layer can be constructed of any of the above mentioned materials.

The primary components of embankment dams are the embankment and foundation; drawdown facility (intake/outlet works); principal spillway; emergency spillway; and the abutments. Related components of the embankment dams which require inspection include the reservoir; downstream channel; power structures (if applicable); and access roads.

SPECIAL TOOL AND EQUIPMENT REQUIREMENTS

No special tools are needed for the Level I and Level II inspection of the embankment dam and/or appurtenant works beyond the requirements listed in the Standard Tools Section and the Special Tools and Equipment Requirements Section for Dams.

If observation of the intake/outlet works requires the structure to be dewatered specifically for the successful performance of the inspection, then the inspection will be performed as part of the regularly scheduled Level III inspection. It should be noted that entry into an intake/outlet works dropshaft or into inlet or outlet conduits require the use of a protective harness with attached safety rope.

15.01 EMBANKMENT DAMS

SPECIAL SAFETY REQUIREMENTS

Since the inspection of an embankment dam and appurtenant works is performed by walking along an embankment and steep slopes adjacent to a reservoir or stream channel, the potential for falling into water or down a slope always exists. Inspection must be performed only after prior notification of the Facility Manager or person responsible for the dam structure, and the inspection personnel must check in with the above personnel upon completion of the inspection process.

Inspection of the intake/outlet works may include observing conditions by boat, if readily available and conditions warrant. If the inspector opts to use a boat, then special safety requirements include the use of a life vest.

Although not required for Level I inspection, any entry into an intake/outlet works structure requires the presence of a minimum of two inspection personnel. Any person entering the intake/outlet works structure must have a safety rope and protective harness, and other safety equipment or measures as required by OSHA and all other agencies having jurisdiction. Inspectors walking across the spillway crest must wear a life preserver where applicable.

Inspection of any power structure built in conjunction with a dam must be performed only after prior notification of the Facility Manager or person responsible for the power structure, and the inspection personnel must check in with the above personnel upon completion of the inspection process. The inspectors must observe all safety requirements posted for work performed inside and around the power structure.

Inspection of any applicable access road may include walking along an access roadway or over a bridge. Passing traffic may be a hazard to the inspectors. The inspection must be performed with the prior approval of the Facility Manager who will notify the authorities to provide safety measures and safe access, if required.

COMPONENT LIST

- 15.01.01 EMBANKMENT
- 15.01.02 INTAKE/OUTLET WORKS
- 15.01.03 SPILLWAY
- 15.01.04 EMERGENCY SPILLWAY
- 15.01.05 RESERVOIR
- 15.01.06 DOWNSTREAM CHANNEL
- 15.01.07 ABUTMENTS
- 15.01.08 POWER STRUCTURES
- 15.01.09 ACCESS ROAD

15.01 EMBANKMENT DAMS

RELATED SUBSYSTEMS

01	BUILDING SUBSTRUCTURE (all subsystems)
02	BUILDING SUPERSTRUCTURE (all subsystems)
03	BUILDING EXTERIOR (all subsystems)
10	BUILDING ELECTRICAL (all subsystems)
16	BRIDGES (all subsystems)
17	TUNNELS (all subsystems)
19	PAVEMENTS/IMPROVED SURFACES (all subsystems)
29	ELECTRICAL DISTRIBUTION (all subsystems)

STANDARD INSPECTION PROCEDURE

Prior to performing a Level I inspection, the inspector(s) should review existing records such as pre-construction investigation records, design criteria and analysis records, available construction records, and photographs taken during initial construction or subsequent site inspections, preceding inspection reports, notes, and photographs, water level records movement monument survey records, and other applicable instrumentation records.

Review of the existing records and data calculated by the planners should result in the Inspector becoming familiarized with the layout, geometric configuration, and dimensions of the dam as well as the historical record of the condition of the dam.

Once the field work commences and prior to the start of the actual recording of observed defect data, it will be necessary for the inspector to establish some measure of stationing along the crest of the dam, along the abutment, and along the intake/outlet works, spillway chute or stilling basin, or other components of the dam as necessary to establish a basis for locating observed defects. Such stationing can match existing stationing shown on existing design or as-built drawings or can be established independently by the inspectors as long as the location of Station 0 + 00 is recorded.

Inspection of an earth or rockfill embankment dam generally involves walking the top, side slopes, downstream toe, and upstream waterline of the dam looking for cracks, erosion, seepage, slumps, slides, condition of slope protection, animal damage, and observing that seepage control structures are operational and not clogged.

Inspection of the intake/outlet works includes noting the physical condition of the mechanical gate control system and an examination of the condition of any exposed surfaces of the structure(s). Inspection of the interior of an intake/outlet works structure is performed during a Level III inspection and requires climbing or crawling into the conduit passing through the embankment where applicable or sized appropriately in order to look for deterioration and/or displacement of the pipe and for seepage conditions.

Observation of spillway or intake/outlet work gate operations is a Level III inspection scope of work item.

In cases where the drawdown facility consists of a conduit passing through the embankment in conjunction with a vertical drop shaft through the dam, the use of divers may be required

15.01 EMBANKMENT DAMS

to place a cover over the upstream end of the conduit and then open the control valve to allow water to pass through the embankment prior to entering the intake/outlet works for inspection. Such inspections will only be performed during regularly scheduled Level III inspections or if observed conditions require the use of advanced test or investigation methods to determine the cause and extent of the problem.

Inspection of the spillway generally involves observing the overflow structure from the downstream side, from the side of the structure, and possibly walking across the control crest. Access to the spillway crest may require the use of a ladder. Any gates which can be readily accessed should be inspected for deterioration and leakage. Inspection of the emergency spillway consists of walking along the approach and outlet channels to observe any debris, erosion, obstructions, vegetation, or sediment which may block or restrict flow to or from the spillway. Inspection also includes observation of existing conditions along the spillway control structure.

Inspection of the reservoir during a Level I inspection includes determination of reservoir levels and observation of conditions along the reservoir rim near the dam looking for indications of erosion, slope instability, or sinkhole development. It is desirable to observe the condition of the reservoir rim during periods of both high and low reservoir levels.

For purposes of the Level I inspection, the downstream channel should be inspected for a distance of 1/4 to 1/2 mile downstream of the existing toe of the dam. Inspection of the downstream channel includes a walk-through to observe that conditions do not exist which could lead to obstruction of flow or pooling of water against the toe of the dam.

Level I inspections of the abutments should include visual inspection of both the left (looking downstream) and right abutment areas, particularly the groin area of the dam at the embankment-natural ground contact. Observations should be made from the crest of the dam or spillway and also from the top and downstream toe of the abutment slope.

A Level I inspection of power structures may be required for purposes of identifying defects which are detrimental to the safe operation or structural integrity of the dam. Such inspection should include observation of the condition of the intake, outlet and penstock structures. Observation of gate structure operations is considered a Level III inspection. Inspection of the power structure generally involves observing the outside condition of the structure from the shoreline and/or dam, as well as general interior conditions of the plant if accessible at the time of inspection.

Inspection of the structure as an operating power producing facility and as a building structure should be carried out by appropriate inspection personnel in accordance with the written Standards for Building Substructure, Building Superstructure, Building Exterior, Building Electrical, and Electrical Distribution.

Observation of actual power generating operations is a Level I inspection which should be performed by appropriate electrical and structural inspector personnel.

Inspection of the access road during a Level I embankment dam inspection is limited to observing the roadway for access to the dam site, and for observing the condition of the pavement, and bridge crossings, if applicable to ensure that passage along the access road is achievable.

15.01 EMBANKMENT DAMS

Pavement condition should be inspected in accordance with the Standard for Pavements and any bridge should be inspected in accordance with the Standard for Bridges.

Photo documentation of existing conditions at the time of inspection is essential to creating a historical record of the condition of the dam over time. Photographs should be taken to record the overall (panorama view) condition of the main components of the dam and appurtenant works as well as to record particular observed defects which are of concern. A record of photographs which have been taken can be input into the Data Collection Device by using the photo log option in the Comments screen. In addition, pertinent additional information which is observed during the Level I inspection, such as location or details of a particular observed defect, should be input into the Comments screen of the Data Collection Device

Help screens have been developed and installed in the Field CAIS program to assist the Inspector during the Level I inspection for dams. Such help screens provide a brief summary of what is required for the inspection of a particular component, as well as a listing of potential defects to be looked for during the inspection. Full descriptions of potential defects are presented in Appendix B.

It is the intent of the standard inspection procedure to document the overall condition of the dam and appurtenant works and to obtain an order of magnitude measure of the quantity of observed defects resulting in a budget projection of cost to repair or replace. The inspector should not focus on obtaining precise measurements. Due to the large scale of the components comprising a dam and to commonly difficult access conditions along a dam, it is often beneficial to estimate the areal or linear extent of a particular defect instead of spending an excessive amount of time trying to obtain an exact measure. It is acknowledged that estimating the unit of measure quantity is somewhat subjective, but doing so, when appropriate to conditions, will save considerable time during the inspection process. The comment screen should be used to indicate any backup data or assumptions made to indicate how the inspector came up with a particular measure of observed defect if necessary.

An example of estimating quantities of defect observations is as follows for debris accumulation covering an embankment dam. A method of estimating the area covered by the debris might be to estimate the percentage of embankment slope covered by debris and multiplying it by the surface area of the slope (already determined through the pre-inspection review of existing information) to obtain an estimated areal extent of observed debris accumulation.

15.01 EMBANKMENT DAMS

COMPONENTS

◆ 15.01.01 EMBANKMENT

The embankment is the primary part of the dam which impounds the water for its intended purposes. The embankment is constructed of excavated natural soil and/or rock materials and can be composed essentially of the same material (homogeneous embankment) or divided into zones of materials having different physical properties (zoned embankment). Most embankments exhibit zoning to some degree with a compacted clayey material forming a relatively impermeable central core. The impermeable clayey zone is generally surrounded, at least on the downstream side, by a more pervious material which will allow drainage. Seepage through the embankment is collected and controlled by means such as chimney drains, drainage blankets, toe drains, rock toes, and relief wells. The embankment slopes are commonly protected by vegetation (crest and downstream slopes) or riprap (upstream and occasionally downstream slope).

The upstream slope can consist of an impermeable membrane or rock shell for rockfill dams, or compacted earthfill protected against wave action. Such slope protection is frequently accomplished by the use of a rock blanket (riprap), soil stabilization, or by construction of a berm. Slope gradients vary depending on the type of materials used and the design of the dam. Existing slope gradients can be found on existing design or construction drawings or can be determined in the field using a Brunton compass.

Potential defects which can be associated with the upstream slope of an embankment dam include displacement of or missing slope protection measures, surface erosion or benching, surface cracking, slope movement, type of vegetation growth, animal burrowing, or debris accumulation.

Depending on the design of the embankment dam, the downstream slope can consist of an earthen slope covered with vegetation or riprap for protection, or a rockfill slope covered with riprap protection. Vegetation should be thick, vigorous growth and short enough to prevent clumping and laying over. There should be no trees on the earth or rock-fill embankment or within approximately 20 feet of the embankment.

Slope gradients can vary depending on the type of materials used and the design of the dam. Existing gradients can be found on existing construction drawings or can be determined in the field using a Brunton compass.

Potential defects which can be readily observed along the downstream slope of an embankment dam include lack of slope protection measures, surface cracking, slope movement, seepage and wet zones with associated piping of sediments, soft zones, surface erosion, type of vegetation growth, animal burrowing, unusual movement or cracking near the toe of slope, clogged toe drains or other pressure relief mechanisms, or measurement monuments not in place.

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.01 EMBANKMENT (Continued)

The crest of the dam is the flat to gently graded top of the embankment. Depending on the design of the dam, the crest is usually covered with grass vegetation or with a layer of gravel. Vehicular traffic may or may not be permitted along the crest of the dam. The length, width, and stationing used along the dam crest is generally found from existing construction drawings; in the case where existing drawings are not available, the dimensions of the crest can be readily measured in the field with a tape measure.

Potential defects which may be observed along the crest of the dam include surface cracking, settlement or horizontal displacement, surface erosion, lack or type of vegetation cover, or animal burrowing or path development.

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Slope Protection - Upstream Slope:**			
Observation:			
a. Less than 10 SF missing, no erosion noted.	SF		
*** {Severity L}			
b. Greater than 10 SF missing, no erosion noted.	SF		
*** {Severity M}			
c. Slope protection missing, erosion noted.	SF		
*** {Severity H}			
Defect:			
*** Surface Erosion/Benching - Upstream Slope:**			
Observation:			
a. Single isolated erosion less than 6" deep.	SF		
*** {Severity L}			
b. Occasional erosion areas, less than 12" deep.	SF		
*** {Severity M}			
c. Erosion greater than 12" deep, or erosion 6" to 12" deep occurring greater than 3 times/20 L.F.	SF		1
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.01 EMBANKMENT (Continued)

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Surface Cracking - Upstream Slope:**			
Observation:			
a. Isolated crack, tight to less than 1/8" in width, above waterline.	EA		
*** {Severity L}			
b. Isolated or several unrelated cracks, 1/8" to 1/2" wide, above waterline.	EA		1
*** {Severity M}			
c. Isolated crack greater than 1/2" in width, multiple interconnected or radiating cracks, or cracks at waterline.	EA		1
*** {Severity H}			
Defect:			
*** Slope Movement - Upstream Slope:**			
Observation:			
a. Soil creep.	SF		
*** {Severity L}			
b. Surface sloughing.	SF		1
*** {Severity M}			
c. Deep seated (greater than 6" depth) movement with well defined boundary.	SF		1
*** {Severity H}			
Defect:			
*** Vegetation Growth - Upstream Slope:**			
Observation:			
a. Short, thick vegetation, needs cutting.	SF		
*** {Severity L}			
b. Sporadic vegetation growth as slope protection.	SF		
*** {Severity M}			
c. Tree or bush growth.	SF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.01 EMBANKMENT (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Animal Damage - Upstream Slope:**			
Observation:			
a. Single burrow, greater than 5 ft above waterline.	SF		
*** {Severity L}			
b. Occasional burrows or paths, greater than 5 ft above waterline.	SF		
*** {Severity M}			
c. Single or numerous burrows, below waterline.	SF		
*** {Severity H}			
Defect:			
*** Debris Accumulation - Upstream Slope:**			
Observation:			
a. Isolated debris accumulation along slope.	SF		
*** {Severity L}			
b. Debris obstructing view of slope.	SF		
*** {Severity M}			
c. Barrels or other debris discharging foreign substance into reservoir or on slope.	EA		
*** {Severity H}			
Defect:			
*** Slope Protection - Downstream Slope:**			
Observation:			
a. Less than 50 SF missing, no erosion noted.	SF		
*** {Severity L}			
b. Greater than 50 SF missing, no erosion noted.	SF		
*** {Severity M}			
c. Slope protection missing, erosion noted.	SF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.01 EMBANKMENT (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Surface Cracking - Downstream Slope:**			
Observation:			
a. Isolated crack, tight to less than 1/8" in width, above waterline.	SF		
*** {Severity L}			
b. Isolated or several unrelated cracks, 1/8" to 1/2" wide, above waterline.	SF		
*** {Severity M}			
c. Isolated crack greater than 1/2" in width, multiple interconnected or radiating cracks.	SF		1
*** {Severity H}			
Defect:			
*** Slope Movement - Downstream Slope:**			
Observation:			
a. Soil creep.	SF		
*** {Severity L}			
b. Surface sloughing.	SF		1
*** {Severity M}			
c. Deep seated (greater than 6" depth) movement with well defined boundary.	SF		1
*** {Severity H}			
Defect:			
*** Seepage/Wet Areas - Downstream Slope:**			
Observation:			
a. Isolated damp or wet spots.	SF		
*** {Severity L}			
b. Numerous seeps less than 1 gpm (seeping out), without piping.	SF		1
*** {Severity M}			
c. Seepage greater than 1 gpm (flowing), or seepage less than 1 gpm with piping.	SF		1
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.01 EMBANKMENT (Continued)

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Soft Zones - Downstream Slope:**			
Observation:			
a. Isolated soft zone above reservoir level.	SF		
*** {Severity L}			
b. Several soft zones along slope.	SF		1
*** {Severity M}			
c. Soft zone near toe of slope.	SF		1
*** {Severity H}			

Defect:

*** Surface Erosion - Downstream Slope:**			
Observation:			
a. Single isolated erosion less than 6" deep.	SF		
*** {Severity L}			
b. Occasional erosion areas, less than 12" deep.	SF		
*** {Severity M}			
c. Erosion greater than 12" deep, or erosion 6" to 12" deep occurring greater than 5 times/20 L.F.	SF		1
*** {Severity H}			

Defect:

*** Vegetation Growth - Downstream Slope:**			
Observation:			
a. Short, thick vegetation, needs cutting.	SF		
*** {Severity L}			
b. Sporadic vegetation growth as slope protection.	SF		
*** {Severity M}			
c. Tree or bush growth	SF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.01 EMBANKMENT (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Animal Damage - Downstream Slope:**			
Observation:			
a. Single burrow, greater than 5 ft above waterline.	SF		
*** {Severity L}			
b. Occasional burrows or paths, greater than 5 ft above waterline.	SF		
*** {Severity M}			
c. Single or numerous burrows, near waterline.	SF		
*** {Severity H}			
Defect:			
*** Unusual Movement/Cracking at Toe of Downstream Slope:**			
Observation:			
a. Single isolated crack less than 3" deep or slump.	LF		
*** {Severity L}			
b. More than one unconnected crack.	SF		1
*** {Severity M}			
c. Numerous interconnected cracks or slumps, or single crack greater than 3" deep.	SF		1
*** {Severity H}			
Defect:			
*** Toe Drains - Downstream Slope:**			
Observation:			
a. Missing protective covers.	EA		
*** {Severity L}			
b. Drain functions, but poor drainage away from pipe.	EA		
*** {Severity M}			
c. Damaged or clogged toe drain.	EA		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.01 EMBANKMENT (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Measurement Monuments - Downstream Slope:**			
Observation:			
a. Monuments not readily visible.	EA		
*** {Severity L}			
b. Missing or disturbed monuments.	EA		1
*** {Severity H}			
Defect:			
*** Surface Cracking - Crest:**			
Observation:			
a. Isolated crack, tight to less than 1/8" in width.	LF		
*** {Severity L}			
b. Isolated or several unrelated cracks, 1/8" to 1/2" in width.	LF		
*** {Severity M}			
c. Isolated crack greater than 1/2" in width, multiple interconnected or radiating cracks.	LF		1
*** {Severity H}			
Defect:			
*** Settlement - Crest:**			
Observation:			
a. Periodic or isolated settlement less than 3" deep.	SF		
*** {Severity L}			
b. Periodic settlement 3" to 6" deep, no cracking.	SF		
*** {Severity M}			
c. Periodic settlement greater than 3" deep with associated cracking.	SF		1
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.01 EMBANKMENT (Continued)

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Horizontal Displacement - Crest:**			
Observation:			
a. Undulating horizontal section of crest.	LF		
*** {Severity L}			
b. Shear zones with vertical and horizontal displacement.	SF		1
*** {Severity M}			
c. Surface rupture, or shear zone with cracking.	SF		1
*** {Severity H}			
Defect:			
*** Surface Erosion - Crest:**			
Observation:			
a. Single isolated erosion less than 6" deep.	SF		
*** {Severity L}			
b. Occasional erosion areas, less than 12" deep.	SF		
*** {Severity M}			
c. Erosion greater than 12" deep, or erosion 6" to 12" deep occurring greater than 3 times/20 L.F.	SF		1
*** {Severity H}			
Defect:			
*** Vegetation Growth - Crest:**			
Observation:			
a. Short, thick vegetation, needs cutting.	SF		
*** {Severity L}			
b. Sporadic vegetation growth as slope protection.	SF		
*** {Severity M}			
c. Tree or bush growth.	SF		
*** {Severity H}			
Defect:			
*** Animal Damage - Crest:**			
Observation:			
a. Single burrow, greater than 5 ft above waterline.	SF		
*** {Severity L}			
b. Single or numerous burrows.	SF		
*** {Severity M}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.02 INTAKE/OUTLET WORKS

The intake/outlet works, or drawdown facility, provide a means for lowering or draining the reservoir. Dams have intake/outlet works in order to control the reservoir pool level, and to lower the reservoir level for repairs to the embankment or in cases when failure of the dam may be imminent.

In general, the intake/outlet facility consists of a pipe extending through the embankment with a valve which may be operated as needed. The drawdown valve should generally be located on the upstream side of the embankment to keep water pressure in the pipe at zero. An exception to this condition is when a vertical drop shaft is incorporated into the design of the intake/outlet works system, whereby the drawdown facility is located at the downstream end of the vertical drop shaft and water is allowed to back up to reservoir level in the vertical pipe riser.

Frequently, the drawdown facility is incorporated into the principal spillway in the form of a gate valve in the riser.

Inspection of an intake/outlet works system requires observation for defects at an intake structure, drop shaft, control system, outlet conduit, stilling basin, and outlet channel. Brief descriptions of these structures follow.

The intake structure is a conduit which permits water to be transported from the reservoir through the embankment. Design of an intake structure can range from an open pipe extending through the upstream embankment slope from the reservoir to a grate covered vertical drop intake shaft to an intake and gatehouse structure.

Potential defects which may be observed at the intake structure include missing trash racks or trash racks covered with debris; deterioration of the concrete or steel intake bulkhead and structure; displacement, settlement or separation of joints in the intake conduit; or leakage into the intake conduit or tower structure.

Where applicable, the drop shaft is a vertical riser which extends from the crest of the dam or point of access along the embankment slope down to the drawdown facility passing through the embankment. The drop shaft can be constructed of formed concrete or consist of a concrete or steel pipe. Details of the drop shaft structure can be obtained from the construction or design drawings or can be readily described and measured in the field.

Potential defects which may be observed in the drop shaft include a missing, broken, or unsecured cover to the drop shaft; deteriorated condition of the exposed top of drop shaft; voids or settlement occurring in the embankment around the pipe risers; deteriorated or missing steps or rungs within the drop shaft; seepage and siltation in the pipe riser; and severe cracking or spalling of the pipe riser.

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.02 INTAKE/OUTLET WORKS (Continued)

The control structure commonly consists of a gate or valve which can be moved across the intake/outlet conduit to control flow from the impoundment. The controls to the gate or valve may be located on the crest of the dam or housed in a gate house facility. Details concerning the control gate or valve can be obtained from the design or construction drawings, or the operations manual, or the type and dimensions can be readily determined in the field.

Potential defects which can be observed concerning the control structure include deterioration of concrete and/or metal and leakage in the gate housing structure; deterioration and wearing of the protective coating on the gate; leakage around the gate when the gate is closed; unsatisfactory operation of the gate machinery during the time of inspection; or missing or broken lock to secure the gate.

The outlet conduit transports water from the inlet pipe and/or drop shaft through the downstream slope of the embankment to the discharge pool. The outlet conduit can be a formed concrete structure or sections of steel or concrete pipe. Details concerning the outlet conduit can be obtained from the design or construction drawings, dam operations manual, or by observing the type and dimensions of the structure in the field.

Potential defects which may be observed in the outlet conduit include debris accumulation in the conduit; severe cracking or spalling of a concrete outlet pipe or deterioration of a steel outlet pipe; leakage (infiltration or exfiltration) in the pipe; vertical or horizontal displacement of the conduit; and lack of erosion protection at the conduit exit.

Depending on the design of the intake/outlet works, the stilling basin can be a separate structure or can be a pool within the downstream channel. The floor of the stilling basin or pool may or may not be visible, depending on tailwater level at the time of inspection. Details and dimensions of the stilling basin can be obtained from the construction drawings or can be determined in the field.

Potential defects which can be observed at the stilling basin include debris accumulation which limits the effectiveness of the outlet works; movement, settlement, or cracking of the stilling basin walls or construction joints; loss of soil behind the stilling basin walls; movement, cracking or displacement of the stilling basin floor; or erosion or undermining beneath the floor slab.

The intake/outlet works exit into the main downstream channel or into a separate outlet channel which converges with the main channel at some distance downstream of the dam. Details concerning a separate outlet channel can be obtained from the design or construction drawings.

Potential defects which can be observed in the outlet channel include missing or displaced slope protection measures; instability of the channel side slopes; or heavy vegetation growth or debris accumulation which obstructs flow through the outlet channel.

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.02 INTAKE/OUTLET WORKS (Continued)

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Trash Racks - Intake Structure:**			
Observation:			
a. Trash racks less than 25% covered by debris. *** {Severity L}	EA		
b. Trash racks 25% to 75% covered by debris. *** {Severity M}	EA		
c. Missing trash rack or greater than 75% covered by debris. *** {Severity H}	EA		
Defect:			
*** General Concrete Condition - Intake Structure (if applicable):**			
Observation:			
a. Spalling, chipped concrete. *** {Severity L}	SF		
b. Cracked concrete structure. *** {Severity M}	SF		
c. Deteriorated concrete with exposed steel reinforcing. *** {Severity H}	SF		
Defect:			
*** Inlet Channel or Conduit (if accessible):**			
Observation:			
a. Pipe displacement, no leakage. *** {Severity L}	LF		
b. Pipe displacement, cumulative leakage less than 5 gpm. *** {Severity M}	LF		2
c. Pipe displacement, cumulative leakage greater than 5 gpm. *** {Severity H}	LF		2

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.02 INTAKE/OUTLET WORKS (Continued)

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Cover/Security - Drop Shaft:**			
Observation:			
a. Unsecured drop shaft cover.	EA		
*** {Severity M}			
b. Missing drop shaft cover.	EA		
*** {Severity H}			
Defect:			
*** General Concrete Condition - Top of Drop Shaft:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Cracked concrete structure.	SF		
*** {Severity M}			
c. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			
Defect:			
*** Voids/Settlement around Pipe Riser - Top of Drop Shaft:**			
Observation:			
a. Observed settlement less than 3".	SF		
*** {Severity L}			
b. Observed settlement greater than 3".	SF		
*** {Severity M}			
c. Combination voids and settlement greater than 3".	SF		2
*** {Severity H}			
Defect:			
*** General Concrete Condition - Gate Housing Structure (if accessible):**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Cracked concrete structure.	SF		
*** {Severity M}			
c. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.02 INTAKE/OUTLET WORKS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Leakage into Gate Housing Structure (if accessible):**			
Observation:			
a. Observed wall dampness.	SF		
*** {Severity L}			
b. Seepage less than 1 gpm.	EA		
*** {Severity M}			
c. Seepage greater than 1 gpm.	EA		2
*** {Severity H}			
Defect:			
*** General Condition of Gate - Control Structure (if accessible):**			
Observation:			
a. Protective gate coating less than 25% missing, little or no deterioration.	EA		
*** {Severity L}			
b. Protective coating 25% to 50% missing, little or no surface deterioration.	EA		
*** {Severity M}			
c. Protective Coating greater than 50% missing, rust or deteriorated steel.	EA		
*** {Severity H}			
Defect:			
*** Leakage Around Gate (in Closed Position) - Control Structure:**			
Observation:			
a. Leakage less than 1 gpm.	EA		
*** {Severity L}			
b. Leakage between 1 gpm and 5 gpm.	EA		
*** {Severity M}			
c. Leakage greater than 5 gpm.	EA		2
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.02 INTAKE/OUTLET WORKS (Continued)

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Gate Operation - Control Works:**			
Observation:			
a. Gate operates with little difficulty, partially opens.	EA		3
*** {Severity L}			
b. Gate does not open or fully close.	EA		3
*** {Severity H}			
Defect:			
*** Gate Security - Control Structure:**			
Observation:			
a. Lock rusted or difficult to open on control system.	EA		
*** {Severity L}			
b. No security measure observed on control system.	EA		
*** {Severity H}			
Defect:			
*** Debris Accumulation - Outlet Conduit:**			
Observation:			
a. Outlet pipe less than 25% blocked by debris.	SF		
*** {Severity L}			
b. Outlet pipe 25% to 75% blocked by debris.	SF		
*** {Severity M}			
c. Outlet pipe greater than 75% blocked by debris.	SF		
*** {Severity H}			
Defect:			
*** General Concrete Condition - Outlet Pipe (if accessible):**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Cracked concrete structure.	SF		
*** {Severity M}			
c. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.02 INTAKE/OUTLET WORKS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Metalwork - Outlet Pipe (if accessible):**			
Observation:			
a. Surface rusting, less than 25% of pipe. *** {Severity L}	LF		
b. Rusting or pitted surface, less than 50% of pipe. *** {Severity M}	LF		
c. Rusting or pitted surface greater than 50% of pipe, or voids or open seams. *** {Severity H}	LF		
Defect:			
*** Vertical/Horizontal Displacement - Outlet Pipe (if accessible):**			
Observation:			
a. Pipe displacement, no leakage. *** {Severity L}	LF		
b. Pipe displacement, cumulative leakage less than 5 gpm. *** {Severity M}	LF		2
c. Pipe displacement, cumulative leakage greater than 5 gpm. *** {Severity H}	LF		2
Defect:			
*** Erosion Protection at Pipe Outlet:**			
Observation:			
a. Erosion protection missing, no erosion noted. *** {Severity M}	SF		
b. Erosion protection missing, erosion noted. *** {Severity H}	SF		

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.02 INTAKE/OUTLET WORKS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Debris Accumulation - Stilling Basin:**			
Observation:			
a. Stilling basin less than 25% blocked by debris.	SF		
*** {Severity L}			
b. Stilling basin 25% to 75% blocked by debris.	SF		
*** {Severity M}			
c. Stilling basin greater than 75% blocked by debris.	SF		
*** {Severity H}			
Defect:			
*** General Concrete Condition (Wall) - Stilling Basin:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			
Defect:			
*** Wall Movement/Settlement - Stilling Basin:**			
Observation:			
a. Differential movement/settlement less than 1/4".	SF		
*** {Severity L}			
b. Differential movement/settlement less than 1".	SF		
*** {Severity M}			
c. Differential movement/settlement greater than 1".	SF		14
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.02 INTAKE/OUTLET WORKS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Wall Construction Joints - Stilling Basin:**			
Observation:			
a. Joint separation less than 1/4" open. *** {Severity L}	LF		
b. Joint separation less than 1" open. *** {Severity M}	LF		
c. Joint separation greater than 1" open. *** {Severity H}	LF		
Defect:			
*** Wall Cracking - Stilling Basin:**			
Observation:			
a. Cracks less than 1/4" open. *** {Severity L}	LF		
b. Cracks between 1/4" and 1" open. *** {Severity M}	LF		
c. Single cracks greater than 1" open. *** {Severity H}	LF		
Defect:			
*** General Concrete Condition (Floor) - Stilling Basin:**			
Observation:			
a. Spalling, chipped concrete. *** {Severity L}	SF		
b. Deteriorated concrete with exposed reinforcing steel. *** {Severity H}	SF		

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.02 INTAKE/OUTLET WORKS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Floor Movement/Settlement - Stilling Basin:**			
Observation:			
a. Differential movement/settlement less than 1/2".	SF		
*** {Severity L}			
b. Differential movement/settlement between 1/2" and 2".	SF		
*** {Severity M}			
c. Differential movement/settlement greater than 2".	SF		15
*** {Severity H}			
Defect:			
*** Floor Construction Joints - Stilling Basin:**			
Observation:			
a. Joint separation less than 1/2" open.	LF		
*** {Severity L}			
b. Joint separation between 1/2" and 1" open.	LF		
*** {Severity M}			
c. Joint separation greater than 1" open.	LF		
*** {Severity H}			
Defect:			
*** Floor Cracking - Stilling Basin:**			
Observation:			
a. Cracks less than 1/2" open.	LF		
*** {Severity L}			
b. Cracks between 1/2" and 1" open.	LF		
*** {Severity M}			
c. Single cracks greater than 1" open.	LF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.02 INTAKE/OUTLET WORKS (Continued)

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Erosion Under Slab - Stilling Basin:**			
Observation:			
a. Voids less than 2" thick.	SF		
*** {Severity L}			
b. Voids 2" to 6" thick.	SF		2
*** {Severity M}			
c. Undercutting of edge of slab, or voids greater than 6" thick.	SF		2
*** {Severity H}			
d. Any void exhibiting piping or erosion of material from under the slab.	SF		2
*** {Severity H}			

Defect:

*** Vegetation/Debris Accumulation - Outlet Channel:**

Observation:			
a. Channel less than 25% blocked by debris.	SF		
*** {Severity L}			
b. Channel 25% to 75% blocked by debris.	SF		
*** {Severity M}			
c. Channel greater than 75% blocked by debris.	SF		
*** {Severity H}			

Defect:

*** Slope Protection - Outlet Channel:**

Observation:			
a. Less than 50 SF missing, no erosion noted.	SF		
*** {Severity L}			
b. Greater than 50 SF missing, no erosion noted.	SF		
*** {Severity M}			
c. Slope protection missing, erosion noted.	SF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.02 INTAKE/OUTLET WORKS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Channel Side Slope Stability - Outlet Channel:**			
Observation:			
a. Soil creep.	SF		
*** {Severity L}			
b. Surface sloughing.	SF		
*** {Severity M}			
c. Rock falls.	SF		
*** {Severity M}			
d. Surface cracking.	SF		
*** {Severity M}			
e. Surface rupture.	SF		2
*** {Severity H}			
f. Landslides.	SF		2
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.03 SPILLWAY

The principal spillway is a structure which passes normal amounts of water past the dam in a safe and non-erosive manner. This spillway can be either, 1) a metal or concrete pipe through the dam incorporating a stand pipe or rise intake structure (as explained in WBS 15.01.02), or 2) a concrete overflow type structure which may or may not be gated.

Inspection of a primary spillway requires observation for defects at the approach channel, control structure, gates, chutes, stilling basin, and outlet channel. Brief descriptions of these structures follow.

Depending on the design of the principal spillway, an overflow structure can have an approach channel which is an arm of the reservoir. Whether an approach channel exists or not for a particular dam can be readily identified in the field.

Potential defects which can be observed in a spillway approach channel include extensive vegetation growth or debris accumulation which obstructs flow through the channel; unstable channel side slopes or large scale stability problems occurring above the immediate channel; lack or displacement of slope protection measures; and erosion of the channel bottom to undermine the control structure.

The control structure typically consists of a concrete overflow structure built into the embankment or placed in a separate channel away from the embankment. Details concerning the type and length of the spillway can be obtained from the construction drawings or can be observed and measured in the field.

Potential defects which can be observed in the control structures include deterioration of the concrete surface of the spillway apron, crest and walls; and movement, settlement, separation or cracking of the spillway apron, crest and walls. Potential defects associated with a pipe extending through the embankment dam are covered in the Standard for Intake/Outlet Works.

The spillway control structure may or may not contain gates. Details concerning the gates at a particular site can be obtained from the design or construction drawings.

Potential defects which can be observed in the gate structures include deterioration of the overall condition and protective coating of the gate; leakage around or under the gate when the gate is closed; malfunctioning gate operating equipment; or missing emergency machinery to operate the gate.

A spillway chute is a discharge channel extending from the crest or toe of the control structure to the stilling basin or terminal structure. Details concerning the chute can be obtained from the construction drawings. The floor of the chute may or may not be visible depending on the amount of water flowing over the spillway.

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.03 SPILLWAY (Continued)

Potential defects which can be observed in the spillway chute include accumulation of debris which can obstruct flow; general concrete deterioration of the walls or floor; movement, settlement, displacement or cracking of the chute floor, walls, and construction joints; seepage into the chute; or erosion or undermining of materials beneath the chute.

The stilling basin is used to decrease the flow velocity of water spilling over the spillway crest and into the outlet channel in order to prevent or minimize scour or erosion of the toe of the dam or damage to adjacent structures. Depending on the design of the spillway and condition of the downstream channel, the stilling basin can be a separate structure or a pool within the downstream or outlet channel. Details and dimensions of the stilling basin can be obtained from the construction drawings or can be determined in the field.

Potential defects which can be observed at the stilling basin include debris accumulation which limits the effectiveness of the spillway; movement, settlement, or cracking of the stilling basin walls or construction joints; loss of soil behind the stilling basin walls; movement, cracking or displacement of the stilling basin floor; or erosion or undermining of soil or rock beneath the floor slab.

Flow from the spillway exits into the main downstream channel or into a separate outlet channel which converges with the main channel at some distance downstream of the dam. The outlet channel dimensions and its need for protection by lining or riprap will depend on the influences of scour on the tailwater. Actual condition of the outlet channel will be readily observable in the field.

Potential defects which can be observed in the outlet channel include heavy vegetation growth or debris accumulation which obstructs flow through the outlet channel; missing or displaced slope protection measures; or channel slope instability which could lead to impoundment or obstruction of the outlet channel.

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Vegetation/Debris Accumulation - Approach Channel:**			
Observation:			
a. Channel less than 25% blocked by debris. *** {Severity L}	SF		
b. Channel 25% to 75% blocked by debris. *** {Severity M}	SF		
c. Channel greater than 75% blocked by debris. *** {Severity H}	SF		
Defect:			
*** Channel Side Slope Stability - Approach Channel:**			
Observation:			
a. Soil creep. *** {Severity L}	SF		
b. Surface sloughing. *** {Severity M}	SF		
c. Rock falls. *** {Severity M}	SF		
d. Surface cracking. *** {Severity M}	SF		
e. Surface rupture. *** {Severity H}	SF		4
f. Landslides. *** {Severity H}	SF		4
Defect:			
*** Slope Movement Above Channel - Approach Channel:**			
Observation:			
a. Soil creep. *** {Severity L}	SF		
b. Surface sloughing. *** {Severity M}	SF		
c. Rock falls. *** {Severity M}	SF		
d. Surface cracking. *** {Severity M}	SF		
e. Surface rupture. *** {Severity H}	SF		4
f. Landslides. *** {Severity H}	SF		4

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Slope Protection - Approach Channel:**			
Observation:			
a. Less than 50 SF missing, no erosion noted.	SF		
*** {Severity L}			
b. Greater than 50 SF missing, no erosion noted.	SF		
*** {Severity M}			
c. Slope protection missing, erosion noted.	SF		
*** {Severity H}			
Defect:			
*** Channel Bottom Erosion - Approach Channel:**			
Observation:			
a. Erosion less than 2 ft deep, not affecting control structure.	SF		
*** {Severity L}			
b. Erosion greater than 2 ft deep, not affecting control structure.	SF		
*** {Severity M}			
c. Channel bottom erosion encroaching on control structure.	SF		4
*** {Severity H}			
Defect:			
*** General Concrete Condition (Apron) - Control Structure:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Cracked concrete structure.	SF		
*** {Severity M}			
c. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Movement/Settlement (Apron) - Control Structure:**			
Observation:			
a. Movement/settlement less than 1/4". *** {Severity L}	SF		
b. Movement/settlement less than 1". *** {Severity M}	SF		
c. Movement/settlement greater than or equal to 1". *** {Severity H}	SF		4
Defect:			
*** Spillway Cracking (Apron) - Control Structure:**			
Observation:			
a. Cracks less than 1/8" open. *** {Severity L}	LF		
b. Cracks between 1/8" and 1/2" open. *** {Severity M}	LF		
c. Single cracks greater than 1/2" open. *** {Severity H}	LF		4
Defect:			
*** Spillway Construction Joints - Control Structure:**			
Observation:			
a. Construction joints less than 1/8" open. *** {Severity L}	LF		
b. Construction joints between 1/8" and 1/2" open. *** {Severity M}	LF		
c. Construction joints greater than 1/2" open. *** {Severity H}	LF		4
Defect:			
*** General Concrete Condition (Crest) - Control Structure:**			
Observation:			
a. Spalling, chipped concrete. *** {Severity L}	SF		
b. Deteriorated concrete with exposed steel reinforcing. *** {Severity H}	SF		

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.03 SPILLWAY (Continued)

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Movement/Settlement (Crest) - Control Structure:**			
Observation:			
a. Movement/settlement less than 1/4". *** {Severity L}	SF		
b. Movement/settlement greater than 1/4" and less than 1". *** {Severity M}	SF		
c. Movement/settlement greater than or equal to 1". *** {Severity H}	SF		4
Defect:			
*** Cracking (Crest) - Control Structure:**			
Observation:			
a. Cracks less than 1/4" open. *** {Severity L}	LF		
b. Cracks between 1/4" and 1" open. *** {Severity M}	LF		
c. Single cracks greater than 1" open. *** {Severity H}	LF		4
Defect:			
*** General Concrete Condition (Walls) - Control Structure:**			
Observation:			
a. Spalling, chipped concrete. *** {Severity L}	SF		
b. Deteriorated concrete with exposed steel reinforcing. *** {Severity H}	SF		4
Defect:			
*** Wall Movement/Displacement - Control Structure:**			
Observation:			
a. Movement/settlement less than 1/4". *** {Severity L}	SF		
b. Movement/settlement less than 1". *** {Severity M}	SF		
c. Movement/settlement greater than or equal to 1". *** {Severity H}	SF		4

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Wall Cracking - Control Structure:**			
Observation:			
a. Cracks less than 1/4" open.	LF		
*** {Severity L}			
b. Cracks between 1/4" and 1" open.	LF		
*** {Severity M}			
c. Single Cracks greater than 1" open.	LF		4
*** {Severity H}			
Defect:			
*** Wall Construction Joints - Control Structure:**			
Observation:			
a. Construction joints less than 1/4" open.	LF		
*** {Severity L}			
b. Construction joints between 1/4" and 1" open.	LF		
*** {Severity M}			
c. Construction joints greater than 1" open.	LF		4
*** {Severity H}			
Defect:			
*** General Condition of Gate:**			
Observation:			
a. Protective gate coating less than 25% missing, little or no deterioration	SF		
*** {Severity L}			
b. Protective coating 25% to 50% missing, none to slight surface deterioration	SF		
*** {Severity M}			
c. Protective coating greater than 50% missing, rust or deteriorated steel.	SF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.03 SPILLWAY (Continued)

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Leakage (with Gate in Closed Position) - Gate:**			
Observation:			
a. Leakage less than 1 gpm.	EA		
*** {Severity L}			
b. Leakage between 1 gpm and 5 gpm.	EA		
*** {Severity M}			
c. Leakage greater than 5 gpm.	EA		
*** {Severity H}			
Defect:			
*** Gate Operation:**			
Observation:			
a. Gate operates with little difficulty, partially opens.	EA		5
*** {Severity L}			
b. Gate does not open or close fully.	EA		5
*** {Severity H}			
Defect:			
*** Emergency Operating Equipment - Gate:**			
Observation:			
a. Equipment available, but in poorly maintained condition.	EA		
*** {Severity L}			
b. Equipment not available.	EA		
*** {Severity H}			
Defect:			
*** Vegetation/Debris Accumulation - Chute:**			
Observation:			
a. Channel less than 25% blocked by debris.	SF		
*** {Severity L}			
b. Channel 25% to 75% blocked by debris.	SF		
*** {Severity M}			
c. Channel greater than 75% blocked by debris.	SF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** General Concrete Condition (Wall) - Chute:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			
Defect:			
*** Wall Movement/Settlement - Chute:**			
Observation:			
a. Movement/settlement less than 1/4".	SF		
*** {Severity L}			
b. Movement/settlement less than 1".	SF		
*** {Severity M}			
c. Movement/settlement greater than or equal to 1".	SF		
*** {Severity H}			
Defect:			
*** Wall Construction Joints - Chute:**			
Observation:			
a. Construction joints less than 1/4" open.	LF		
*** {Severity L}			
b. Construction joints between 1/4"and 1" open.	LF		
*** {Severity M}			
c. Construction joints greater than 1" open.	LF		
*** {Severity H}			
Defect:			
*** Wall Cracking - Chute:**			
Observation:			
a. Cracks less than 1/4" open.	LF		
*** {Severity L}			
b. Cracks between 1/4"and 1" open.	LF		
*** {Severity M}			
c. Single cracks greater than 1" open.	LF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** General Concrete Condition (Floor) - Chute:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			
Defect:			
*** Floor Construction Joints - Chute:**			
Observation:			
a. Joint separation less than 1/4" open.	LF		
*** {Severity L}			
b. Joint separation between 1/4" and 1" open.	LF		
*** {Severity M}			
c. Joint separation greater than 1" open.	LF		
*** {Severity H}			
Defect:			
*** Floor Movement/Settlement - Chute:**			
Observation:			
a. Movement/settlement less than 1/4".	SF		
*** {Severity L}			
b. Movement/settlement less than 1".	SF		
*** {Severity M}			
c. Movement/settlement greater than 1".	SF		
*** {Severity H}			
Defect:			
*** Floor Cracking - Chute:**			
Observation:			
a. Cracks less than 1/4" open.	LF		
*** {Severity L}			
b. Cracks between 1/4"and 1" open.	LF		
*** {Severity M}			
c. Single cracks greater than 1" open.	LF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Seepage - Chute:**			
Observation:			
a. Observed wall dampness.	SF		
*** {Severity L}			
b. Seepage less than 1 gpm.	SF		
*** {Severity M}			
c. Seepage greater than 1 gpm.	SF		4
*** {Severity H}			
Defect:			
*** Undermining - Chute:**			
Observation:			
a. Voids less than 2" thick	SF		
*** {Severity L}			
b. Voids 2" to 6" thick	SF		4
*** {Severity M}			
c. Undercutting of edge of slab, or voids greater than 6" thick	SF		4
*** {Severity H}			
d. Any voids exhibiting signs of piping or erosion of materials beneath slab.	SF		4
*** {Severity H}			
Defect:			
*** Vegetation/Debris Accumulation - Stilling Basin:**			
Observation:			
a. Channel less than 25% blocked by debris.	SF		
*** {Severity L}			
b. Channel 25% to 75% blocked by debris.	SF		
*** {Severity M}			
c. Channel greater than 75% blocked by debris.	SF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** General Concrete Condition (Wall) - Stilling Basin:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			
Defect:			
*** Wall Movement/Settlement - Stilling Basin:**			
Observation:			
a. Differential movement/settlement less than 1/4".	SF		
*** {Severity L}			
b. Differential movement/settlement less than 1".	SF		
*** {Severity M}			
c. Differential movement/settlement greater than 1".	SF		14
*** {Severity H}			
Defect:			
*** Wall Construction Joints - Stilling Basin:**			
Observation:			
a. Construction joints less than 1/4" open.	LF		
*** {Severity L}			
b. Construction joints between 1/4"and 1" open.	LF		
*** {Severity M}			
c. Construction joints greater than 1" open.	LF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** General Concrete Condition (Floor) - Stilling Basin:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			
Defect:			
*** Floor Cracking - Stilling Basin:**			
Observation:			
a. Cracks less than 1/4" open.	LF		
*** {Severity L}			
b. Cracks between 1/4"and 1" open.	LF		
*** {Severity M}			
c. Single cracks greater than 1" open.	LF		
*** {Severity H}			
Defect:			
*** Floor Movement/Settlement - Stilling Basin:**			
Observation:			
a. Differential movement/settlement less than 1/4".	SF		
*** {Severity L}			
b. Differential movement/settlement less than 1".	SF		
*** {Severity M}			
c. Differential movement/settlement greater than or equal to 1".	SF		15
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Floor Construction Joints - Stilling Basin:**			
Observation:			
a. Joint separation less than 1/4" open. *** {Severity L}	LF		
b. Joint separation between 1/4" and 1" open. *** {Severity M}	LF		
c. Joint separation greater than 1" open. *** {Severity H}	LF		
Defect:			
*** Undermining of Floor Slab - Stilling Basin:**			
Observation:			
a. Voids less than 2" thick *** {Severity L}	SF		
b. Voids 2" to 6" thick *** {Severity M}	SF		4
c. Undercutting of edge of slab, or voids greater than 6" thick *** {Severity H}	SF		4
d. Any voids exhibiting signs of piping or erosion of material beneath slab.	SF		4
Defect:			
*** Vegetation/Debris Accumulation - Outlet Channel:**			
Observation:			
a. Channel less than 25% blocked by debris. *** {Severity L}	SF		
b. Channel 25% to 75% blocked by debris. *** {Severity M}	SF		
c. Channel greater than 75% blocked by debris. *** {Severity H}	SF		

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Slope Protection - Outlet Channel (if applicable):**			
Observation:			
a. Less than 50 SF missing, no erosion noted.	SF		
*** {Severity L}			
b. Greater than 50 SF missing, no erosion noted.	SF		
*** {Severity M}			
c. Slope protection missing, erosion noted.	SF		
*** {Severity H}			
Defect:			
*** Channel Slope Stability - Outlet Channel:**			
Observation:			
a. Soil creep.	SF		
*** {Severity L}			
b. Surface sloughing.	SF		
*** {Severity M}			
c. Rock falls.	SF		
*** {Severity M}			
d. Surface cracking.	SF		
*** {Severity M}			
e. Surface rupture.	SF		4
*** {Severity H}			
f. Landslides.	SF		4
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.04 EMERGENCY SPILLWAY

The emergency spillway functions during periods of flooding and extremely high reservoir levels to prevent overtopping of the dam. Typically, the emergency spillway is a channel excavated in earth or rock which is located a safe distance away from the embankment eventually enters the downstream channel some distance downstream of the dam. Channels excavated in earth or easily erodible rock frequently have concrete control sections and chutes. On dams with combined principal and emergency spillways, concrete structures are common. The exit channel of an emergency spillway should be located a sufficient distance from the dam to preclude damage to the embankment or appurtenant works should the spillway be used. The location and dimensions of the emergency spillway can be found in the design or construction drawings.

Inspection of an emergency spillway requires observation of defects at the approach channel, the control structure, and the outlet channel. Brief descriptions of these components follow.

The approach channel to the emergency spillway is that part of the excavated channel upstream of the control structure. During periods of normal or low reservoir level, this approach channel may be readily observable. In contrast, this same channel will appear to be a branch of the existing reservoir during periods of high reservoir levels.

Potential defects which can be observed in the emergency spillway approach channel include extensive vegetation growth or debris accumulation which obstructs flow through the channel; unstable channel side slopes or large scale stability problems occurring in slopes above the immediate channel; lack or displacement of slope protection measures; and erosion of the channel bottom which threatens to undermine the control structure.

The control structure typically consists of one of the following: 1. a concrete sill and chute placed across the width of the emergency spillway channel; 2. soil or rock excavated to form a high point along the emergency spillway channel; or 3. a concrete structure as part of a combined principal/emergency spillway. Details concerning the control structure can be obtained from design or construction drawings or can be observed and measured in the field.

Potential defects of the control structure which can be observed include deterioration of the concrete; settlement of the control sill; erosion and undermining of the control sill; or defects associated with the concrete spillway apron and crest as set forth in the Standard for Spillways.

Flow from the emergency spillway channel generally exits in a separate outlet channel which converges with the main downstream channel at some distance downstream from the dam site. Actual outlet channel conditions will be readily observable in the field.

Potential defects which can be observed in an outlet channel include heavy vegetation growth or debris accumulation which obstructs flow through the outlet channel; missing or displaced slope protection measures or rapid progression of erosion upstream towards the control structure; or channel slope instability which could lead to impoundment or obstruction of flow through the outlet channel.

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.04 EMERGENCY SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Vegetation/Debris Accumulation - Approach Channel:**			
Observation:			
a. Channel less than 25% blocked by debris. *** {Severity L}	SF		
b. Channel 25% to 75% blocked by debris. *** {Severity M}	SF		
c. Channel greater than 75% blocked by debris. *** {Severity H}	SF		
Defect:			
*** Channel Slope Stability - Approach Channel:**			
Observation:			
a. Soil creep. *** {Severity L}	SF		
b. Surface sloughing. *** {Severity M}	SF		
c. Rock falls. *** {Severity M}	SF		
d. Surface cracking. *** {Severity M}	SF		
e. Surface rupture. *** {Severity H}	SF		6
f. Landslides. *** {Severity H}	SF		6

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.04 EMERGENCY SPILLWAY (Continued)

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Slope Movement Above Channel - Approach Channel:**			
Observation:			
a. Soil creep.	SF		
*** {Severity L}			
b. Surface sloughing.	SF		
*** {Severity M}			
c. Rock falls.	SF		
*** {Severity M}			
d. Surface cracking.	SF		
*** {Severity M}			
e. Surface rupture.	SF		6
*** {Severity H}			
f. Landslides.	SF		6
*** {Severity H}			
Defect:			
*** Slope Protection (if applicable) - Approach Channel:**			
Observation:			
a. Less than 50 SF missing, no erosion noted.	SF		
*** {Severity L}			
b. Greater than 50 SF missing, no erosion noted.	SF		
*** {Severity M}			
c. Slope protection missing, erosion noted.	SF		
*** {Severity H}			
Defect:			
*** Sedimentation - Approach Channel:**			
Observation:			
a. Sediment accumulation below control structure level.	SF		
*** {Severity M}			
b. Sediment accumulation higher than control structure level.	SF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.04 EMERGENCY SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** General Concrete Condition (Crest) - Control Structure:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Cracked concrete structure.	SF		
*** {Severity M}			
c. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			
d. Eroded soil or rock control structure	SF		6
*** {Severity H}			
Defect:			
*** Movement/Settlement of Crest - Control Structure:**			
Observation:			
a. Movement/settlement less than 1/4".	SF		
*** {Severity L}			
b. Movement/settlement less than 1".	SF		
*** {Severity M}			
c. Movement/settlement greater than or equal to 1".	SF		
*** {Severity H}			
Defect:			
*** Undermining of Control Structure:**			
Observation:			
a. Voids less than 2" thick	SF		
*** {Severity L}			
b. Voids 2" to 6" thick	SF		6
*** {Severity M}			
c. Undercutting of edge of slab, or voids greater than 6" thick	SF		6
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.04 EMERGENCY SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Vegetation/Debris Accumulation - Outlet Channel:**			
Observation:			
a. Channel less than 25% blocked by debris. *** {Severity L}	SF		
b. Channel 25% to 75% blocked by debris. *** {Severity M}	SF		
c. Channel greater than 75% blocked by debris. *** {Severity H}	SF		
Defect:			
*** Channel Slope Stability - Outlet Channel:**			
Observation:			
a. Soil creep. *** {Severity L}	SF		
b. Surface sloughing. *** {Severity M}	SF		
c. Rock falls. *** {Severity M}	SF		
d. Surface cracking. *** {Severity M}	SF		
e. Surface rupture. *** {Severity H}	SF		6
f. Landslides. *** {Severity H}	SF		6
Defect:			
*** Slope Protection (if applicable) - Outlet Channel:**			
Observation:			
a. Less than 50 SF missing, no erosion noted. *** {Severity L}	SF		
b. Greater than 50 SF missing, no erosion noted. *** {Severity M}	SF		
c. Slope protection missing, erosion noted. *** {Severity H}	SF		

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.05 RESERVOIR

The reservoir is the impoundment of water formed by the blockage of an existing river or stream by the embankment dam.

Conditions which require observation during inspection of the reservoir include the reservoir level, and landslides or beach erosion around the rim of the reservoir. Brief descriptions of conditions to look for while observing the reservoir follow.

Reservoir levels can be determined by observing the reservoir level gauge set up adjacent to the embankment or spillway, or located on a structure within the reservoir.

Potential defects associated with observed reservoir levels include a missing or malfunctioning reservoir level gauge, the reservoir level being either too high or too low, or observance of whirlpools or vortexes in the reservoir near the embankment or reservoir rim which may indicate loss of water from the reservoir to some unknown location.

Landslides are a potential problem for reservoirs. Instability of the slopes above the reservoir have resulted in instances where landslides have fallen into the reservoir, causing a repercussive wave which overtops the dam and causes significant consequences to the downstream environment. Identification of conditions leading to large scale movement is difficult and requires some degree of expertise in the observation and evaluation of landslides. The object of the inspection of the reservoir rim for the periodic maintenance inspection is to identify and locate areas where landslides have already occurred and estimate its size.

Beach erosion along the rim of the reservoir is generally the result of wind driven waves encountering the surrounding ground surface. Beach erosion can lead to instability of adjacent reservoir rim slopes or, in extreme cases, form a new outlet for the reservoir through erosion or uncovering outlets through sinkholes.

Potential defects include excessive erosion along the rim of the reservoir as well as the uncovering or development of sinkholes or depressions along the reservoir rim.

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Reservoir Level Gauge:**			
Observation:			
a. Reservoir level gauge not completely legible. *** {Severity L}	EA		
b. Reservoir level gauge missing or broken. *** {Severity H}	EA		

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.05 RESERVOIR (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Reservoir Level Too High:**			
Observation:			
a. Reservoir level encroaches on design freeboard.	EA		
***{Severity L}			
b. Reservoir level within 3 ft of top of dam.	EA		
***{Severity H}			
Defect:			
*** Reservoir Level Too Low:**			
Observation:			
a. Reservoir level between 3 ft or less above the control elevation.	EA		
*** {Severity M}			
b. Reservoir is dry for unexplainable reason.	EA		7
*** {Severity H}			
Defect:			
*** Whirlpools (in Reservoir):**			
Observation:			
a. Whirlpool located greater than 200 ft from dam.	EA		7
*** {Severity L}			
b. Whirlpool less than 200 ft from dam due to intake operations.	EA		7
*** {Severity M}			
c. Unexplained observed whirlpools less than 200 ft from dam.	EA		7
*** {Severity H}			
Defect:			
*** Landslides - Reservoir Rim:**			
Observation:			
a. Old or ancient landslide scars.	EA		7
*** {Severity L}			
b. Observed landslide not recorded during last inspection.	EA		7
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.05 RESERVOIR (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Beach Erosion - Reservoir Rim:**			
Observation:			
a. Erosion causing instability of reservoir rim slopes.	SF		7
*** {Severity M}			
b. Erosion nearly progressed to reservoir control level.	SF		7
*** {Severity H}			
Defect:			
*** Sinkholes/Surface Depressions - Reservoir Rim:**			
Observation:			
a. Sinkholes located above high water level of reservoir.	SF		7
*** {Severity M}			
b. Sinkholes within high water level reach of reservoir.	SF		7
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.06 DOWNSTREAM CHANNEL

The downstream channel is the original stream bed or river channel located downstream of the embankment dam. Different regulations have varying definitions for what qualifies as a "downstream environment zone"; however, in general, the downstream environment zone is defined as the area downstream from a dam that would be affected by inundation in the event the dam failed when filled to the maximum level attained during a Probable Maximum Flood event or to the dam crest elevation, whichever is lower.

The downstream channel should be relatively free draining. Pools of water should not be allowed to pond against the toe of the embankment dam.

Potential defects which can be observed in the downstream channel include vegetation growth, debris accumulation, or development of animal habitat which could obstruct flow through the channel; signs of erosion progressing upstream towards the toe of the dam; seepage through the dam or abutments which flows into the channel; or signs of sand boils or water plumes in the downstream channel.

The side slopes of the downstream channel are critical in that they must exhibit some degree of stability so that material will not fall into and block flow through the downstream channel. The channel slopes are generally comprised of soil, rock, or mixture of both.

Potential defects which should be looked for in the side slopes of the downstream channel include landslides, surface sloughing, and other signs of channel slope instability; slope erosion; and seepage passing from the reservoir through the abutment areas and exiting the downstream channel side slopes.

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Vegetation/Debris Accumulation - Downstream Channel:**			
Observation:			
a. Channel less than 25% blocked by debris.	SF		
*** {Severity L}			
b. Channel 25% to 75% blocked by debris.	SF		
*** {Severity M}			
c. Channel greater than 75% blocked by debris.	SF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.06 DOWNSTREAM CHANNEL (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Animal Habitat - Downstream Channel:**			
Observation:			
a. Animal habitat blocking less than 25% of channel.	SF		
*** {Severity L}			
b. Animal habitat blocking 25% to 75% of channel.	SF		
*** {Severity M}			
c. Animal habitat blocking greater than 75% of channel or impounding water against toe of dam.	SF		
*** {Severity H}			
Defect:			
*** Channel Erosion - Downstream Channel:**			
Observation:			
a. Erosion causing slope stability problems greater than 200 ft downstream of dam.	SF		
*** {Severity L}			
b. Erosion causing slope stability problems less than 200 ft downstream of dam.	SF		8
*** {Severity M}			
c. Erosion encroaching on toe of dam.	SF		8
*** {Severity H}			
Defect:			
*** Seepage - Downstream Channel:**			
Observation:			
a. Seepage occurs greater than 100 ft downstream of dam.	SF		
*** {Severity L}			
b. Seepage occurs between 50 ft and 100 ft downstream of dam.	SF		8
*** {Severity M}			
c. Seepage occurs less than 50 ft downstream of dam.	SF		8
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.06 DOWNSTREAM CHANNEL (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Sand Boils/Water Plumes - Downstream Channel:**			
Observation:			
a. Sand boils/water plumes observed greater than 500 ft downstream of dam.	EA		
*** {Severity L}			
b. Sand boils/water plumes observed between 50 ft and 500 ft downstream of dam.	EA		8
*** {Severity M}			
c. Sand boils/water plumes observed less than 50 ft downstream of dam.	EA		8
*** {Severity H}			
Defect:			
*** Channel Slope Stability - Side Slopes:**			
Observation:			
a. Soil creep.	SF		
*** {Severity L}			
b. Surface sloughing.	SF		
*** {Severity M}			
c. Rock falls.	SF		
*** {Severity M}			
d. Surface cracking.	SF		
*** {Severity M}			
e. Surface rupture.	SF		8
*** {Severity H}			
f. Landslides.	SF		8
*** {Severity H}			
Defect:			
*** Slope Protection (if applicable) - Side Slopes:**			
Observation:			
a. Less than 100 SF missing, no erosion noted.	SF		
*** {Severity L}			
b. Greater than 100 SF missing, no erosion noted.	SF		
*** {Severity M}			
c. Slope protection missing, erosion noted.	SF		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.06 DOWNSTREAM CHANNEL (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Seepage - Side Slopes:**			
Observation:			
a. Seepage occurs greater than 100 ft downstream of dam.	SF		
*** {Severity L}			
b. Seepage occurs between 50 ft and 100 ft downstream of dam.	SF		8
*** {Severity M}			
c. Seepage occurs less than 50 ft downstream of dam.	SF		8
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.07 ABUTMENTS

Abutment areas are the contact points between the ends of the embankment dam or spillway and the natural ground. The natural ground at these locations can be comprised of soil or rock. These areas should be closely and frequently inspected for any signs of seepage, cracks or erosion. Observation of any of these conditions should prompt an engineering inspection so that an assessment of the safety of the dam can be determined and a baseline measurement can be established to assist in identifying whether the problem is intensifying.

Potential defects to be looked for include erosion of the abutments; seepage; and instability of the abutments due to landslides, surface sloughing, soil creep, rock falls, surface cracking, or surface rupture.

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Slope Stability - Left Abutment:**			
Observation:			
a. Soil creep.	SF		
*** {Severity L}			
b. Surface sloughing.	SF		
*** {Severity M}			
c. Rock falls.	SF		
*** {Severity M}			
d. Surface cracking.	SF		
*** {Severity M}			
e. Surface rupture.	SF		9
*** {Severity H}			
f. Landslides.	SF		9
*** {Severity H}			
Defect:			
*** Surface Erosion - Left Abutment:**			
Observation:			
a. Single isolated erosion less than 6" deep, not compromising the stability of the abutment.	SF		
*** {Severity L}			
b. Occasional erosion areas, less than 12" deep.	SF		9
*** {Severity M}			
c. Erosion greater than or equal to 12" deep, or erosion 6" to 12" deep occurring greater than 3 times/20 LF.	SF		9
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.07 ABUTMENTS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Seepage - Left Abutment:**			
Observation:			
a. Damp or wet spots.	SF		
*** {Severity M}			
b. Observed seepage.	SF		9
*** {Severity H}			
Defect:			
*** Slope Stability - Right Abutment:**			
Observation:			
a. Soil creep.	SF		
*** {Severity L}			
b. Surface sloughing.	SF		
*** {Severity M}			
c. Rock falls.	SF		
*** {Severity M}			
d. Surface cracking.	SF		
*** {Severity M}			
e. Surface rupture.	SF		9
*** {Severity H}			
f. Landslides.	SF		9
*** {Severity H}			
Defect:			
*** Surface Erosion - Right Abutment:**			
Observation:			
a. Single isolated erosion less than 6" deep, not compromising the stability of the abutment.	SF		
*** {Severity L}			
b. Occasional erosion areas, less than 12" deep.	SF		9
*** {Severity M}			
c. Erosion greater than 12" deep or erosion 6" to 12" deep occurring greater than 3 times/20 LF.	SF		9
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.07 ABUTMENTS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Seepage - Right Abutment:**			
Observation:			
a. Damp or wet spots.	SF		
*** {Severity M}			
b. Observed seepage.	SF		9
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.08 POWER STRUCTURE

Due to its capacity to store and discharge water, many embankment dams include hydroelectric power plant facilities. These power structures should be inspected during a periodic maintenance inspection if the structures are related to the safe operation or structural integrity of the dam.

Inspection of a power structure requires observation of defects, where applicable, at the intake structure, penstocks, and tail race. Brief descriptions of these components follow.

The intake structure is the facility where water from the reservoir enters the power plant. Configurations for the intake structure can vary considerably, but in each case, will include some type of control intake gate structure. Details concerning the intake structure are found in the design or construction drawings.

Potential defects which should be looked for during inspection of the intake structure include accumulation of debris on the trash racks which could hinder flow into the intake structure; deteriorated condition of the gate and its protective coating; lack of posted instructions to operate the gate; or faulty performance in gate operation during time of inspection. Inspection of the electrical and mechanical aspects of the intake gate hoist should be performed in accordance with Standards for Building Electrical and Electrical Distribution.

The penstock is a pipeline or pressure shaft leading from the headrace or reservoir to the turbines housed in a power plant structure. Details concerning the penstock can be obtained from the design and construction drawings.

A Level I inspection of a penstock includes observations for deterioration, cracking or movement of the power plant walls and substructure. This inspection is to be performed only if it is determined that the power structure is related to the safe operation or structural integrity of the dam and is only performed to document existing general structural conditions which are readily observable.

Detailed inspection of the power plant structure should be performed by structural inspectors in accordance with Standards for Building Substructure, Building Superstructure, and Building Exterior. Due to varying penstock designs, the penstock may not be readily accessible for a Level I inspection. If such is the case, then a Level III inspection will be required.

Potential defects which could be observed in the penstock and power house structure include cracking, settlement, or displacement of the powerhouse and penstock walls or substructure, or leakage or observed displacement of the penstock structure.

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.08 POWER STRUCTURE (Continued)

The tail race is a tunnel, channel or conduit that conveys the discharge from a powerplant turbine to the river.

Where accessible, a Level I inspection of the tail race should include observation for existing surface defects such as cracking, displacement or leakage. This inspection is to be performed only if it is determined that the power structure is related to the safe operation or structural integrity of the dam and is only performed to document existing general structural conditions which are readily observable.

Detailed inspection of the tail race should be performed by structural inspectors in accordance with Standards for Tunnels. Due to varying designs, the tail race may not be readily accessible for a Level I inspection. If such is the case, then an inspection will be performed during a regularly scheduled Level III inspection will be required.

Potential defects which could be observed in the tail race include cracking, settlement, or displacement of the tail race structure or observed leakage along the tail race.

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Trash Rack - Intake Structure:**			
Observation:			
a. Trash rack less than 25% obstructed by debris.	EA		
*** {Severity L}			
b. Trash rack 25% to 75% obstructed by debris.	EA		
*** {Severity M}			
c. Missing trash rack or greater than 75% obstructed by debris.	EA		
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.08 POWER STRUCTURE (Continued)

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** General Condition of Intake Gate - Intake Structure:**			
Observation:			
a. Protective gate coating less than 25% missing, little or no deterioration	SF		
*** {Severity L}			
b. Protective coating 25% to 50% missing, none to slight surface deterioration	SF		
*** {Severity M}			
c. Protective Coating greater than 50% missing, rust or deteriorated steel.	SF		
*** {Severity H}			
Defect:			
*** Gate Operation at Time of Inspection - Intake Structure:**			
Observation:			
a. Gate operates with little difficulty, partially opens.	EA		10
*** {Severity L}			
c. Gate does not open or fully close.	EA		10
*** {Severity H}			
Defect:			
*** Penstock/Power Structure Walls:**			
Observation:			
a. Walls exhibit cracking	SF		11
*** {Severity L}			
b. Walls exhibit displacement or settlement.	SF		11
*** { Severity M}			
c. Walls exhibit leakage.	SF		11
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.08 POWER STRUCTURE (Continued)

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Penstock/Power Structure Floor:**			
Observation:			
a. Floor or exposed foundations exhibit cracking. *** {Severity L}	SF		11
b. Floor or exposed foundations exhibit displacement or settlement. *** { Severity M}	SF		11
c. Floor exhibits seepage. *** {Severity H}	SF		11
Defect:			
*** Tail Race Structure:**			
Observation:			
a. Tail race exhibits cracking. *** {Severity L}	SF		11
b. Tail race exhibits displacement or settlement. *** { Severity M}	SF		11
c. Tail race exhibits leakage. *** {Severity H}	SF		11
Defect:			
*** Tail Race Bulkhead:**			
Observation:			
a. Bulkhead exhibits cracking. *** {Severity L}	SF		11
b. Bulkhead exhibits displacement or settlement. *** { Severity M}	SF		11
c. Bulkhead exhibits leakage. *** {Severity H}	SF		11

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ 15.01.09 ACCESS ROADS

Access roads to the dam site should be kept open at all times other than to perform maintenance work on an as-needed basis. As part of the Level I inspection, the access road should be inspected if it is located along the crest of the embankment dam or where it crosses the downstream channel. Full inspection of the access road should be performed under the Standard prepared for Pavements/Improved Surfaces.

Level I inspection should be performed to ensure that the access roadway is clear for emergency vehicular traffic. Any temporary closures or blockages of the access road due to maintenance or construction work activities should be noted.

Potential defects which could be observed along an access road include blockage of the roadway due to fallen trees, rocks, or debris, to such condition that passage of emergency vehicles may be difficult.

Any bridges along the access road should be briefly inspected during the Level I inspection to ensure that passage along the roadway is achievable. Full scale inspections of the bridge should be performed in accordance to the frequency and conditions set forth in the Standards for Bridges.

Potential defects which should be looked for during the Level I inspection include deterioration of the general condition of the bridge to such extent that the bridge will not be accessible to traffic during an emergency condition.

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Roadway Clearance - Access Road:**			
Observation:			
a. Roadway temporarily blocked due to maintenance or construction activity.	LF		
*** {Severity L}			
b. Long term blockage due to slope instability or deteriorated pavement.	LF		12
*** {Severity H}			

15.01 EMBANKMENT DAMS

COMPONENTS (Continued)

◆ **15.01.09 ACCESS ROADS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Debris Accumulation/Obstruction:**			
Observation:			
a. Roadway partially blocked by debris.	LF		
*** {Severity L}			
b. Roadway greater than 75% blocked by debris.	LF		
*** {Severity M}			
Defect:			
*** General Bridge Condition (if applicable):**			
Observation:			
a. Bridge accessible to traffic partially blocked.	EA		12
*** {Severity M}			
b. Bridge inaccessible to traffic.	EA		12
*** {Severity H}			

15.01 EMBANKMENT DAMS

REFERENCES

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993.

2. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982.

3. EM 1110-2-1902, Stability of Earth and Rock-Fill Dams, April 1, 1970, Includes Change 1.

4. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

5. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

6. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

7. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

8. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

9. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

10. Engineering Foundation Conference Proceedings, Inspection, Maintenance and Rehabilitation of Old Dams, American Society of Civil Engineers, 1973.

11. American Society of Civil Engineers and United States Committee on Large Dams, Joint ASCE-USCOLD Committee on Current United States Practice in the Design and Construction of Arch Dams, Embankment Dams, and Concrete Gravity Dams, 1967.

12. Engineering Foundation Conference Proceedings, The Evaluation of Dam Safety, American Society of Civil Engineers, 1976.

13. Glossary of Geology, Second Edition, American Geological Institute, 1980.

15.01 EMBANKMENT DAMS

REFERENCES(Continued)

14. U.S. Department of the Interior Bureau of Reclamation, General Checklist for Examination of Embankment Dams.

15. U.S. Army Corps of Engineers, ER 1110-2-106, Recommended Guidelines for Safety Inspection of Dams, September 1979.

16. Procedural Guidelines for Preparation of Technical Data to be included in Application for Permits for Construction and Maintenance of Dams, Illinois Department of Transportation, Division of Water Resources, 1987.

17. Rules and Regulations of the Missouri Dam and Reservoir Safety Council, Missouri Department of Natural Resources Division of Geology and Land Survey.

18. Engineering Guidelines for the Evaluation of Hydropower Projects, Federal Energy Regulatory Commission Office of Hydropower Licensing, April 1991.

19. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987.

15.01 EMBANKMENT DAMS

LEVEL II KEY	GUIDE SHEET CONTROL NUMBER

N/A

LEVEL III KEY	GUIDE SHEET CONTROL NUMBER
1	GS-III 15.01.01-1
2	GS-III 15.01.02-2
3	GS-III 15.01.02-3
4	GS-III 15.01.03-4
5	GS-III 15.01.03-5
6	GS-III 15.01.04-6
7	GS-III 15.01.05-7
8	GS-III 15.01.06-8
9	GS-III 15.01.07-9
10	GS-III 15.01.08-10
11	GS-III 15.01.08-11
12	GS-III 15.01.09-12
*13	GS-III 15.01-13
14	GS-III 15.01.20-14
15	GS-III 15.01.24-15

* *Indicates Guide Sheets which are not directly referenced with a Key. These inspections are "triggered" by conditions beyond the inspection process such as time, age or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 1

COMPONENT: EMBANKMENT
CONTROL NUMBER: GS-III 15.01.01-1

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of defects recorded in Level I or Level II defect observations of the embankment dam.

Whereas the purpose of the Level I inspection was to record the observable defects at readily accessible sections of the embankment, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam and it's appurtenant works.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multi-disciplined team of engineers experienced in the design and construction of embankment dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing deficiency conditions of the embankment or to require continued monitoring of existing deficiency conditions at the embankment.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III test and inspection method. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Embankment Dams.

For inspection work performed by boat, the inspection team shall consists of a minimum of two personnel.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 1 (Continued)

COMPONENT: EMBANKMENT
CONTROL NUMBER: GS-III 15.01.01-1

Inspection Actions

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

2. Perform inspection of the pertinent components where observed defects that triggered a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance, or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimate for required maintenance or remedial repair measures, as applicable.

Level III advanced inspection methods may be required for many different Level I and Level II defect conditions observed at an embankment dam site. Level III advanced test or inspection methods and associated observed defects for an embankment dam include, but are not limited to the following:

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 1 (Continued)

COMPONENT: EMBANKMENT
CONTROL NUMBER: GS-III 15.01.01-1

Non-Standard Test or Inspection Method	Applicable Observed Defects
1. backhoe excavations	embankment settlement, soft zones, slope instability, sedimentation accumulation
2. dye testing	seepage
3. piezometer installation	slope instability, seepage, wet zones
4. relief wells	wet zones, clogged toe drains, seepage
5. soil borings	slope instability, embankment cracking, settlement, undermining, erosion
6. laboratory tests on soil samples (strength tests, moisture content, consolidation tests, etc.)	slope instability
7. infrared thermography	voids, sinkholes, seepage, poor drainage
8. ground probing radar	voids
9. slope inclinometers	slope stability, measurement monument, embankment or structural displacement
10. slope movement monuments	slope movement, slope stability
11. crest settlement monuments	crest settlement
12. erosion survey monuments	extensive or rapidly progressing erosion in downstream channels, upstream embankment slope, abutments
13. flow measurement readings	seepage, leakage
14. survey measurements	existing drawings do not match field observations, baseline for erosion monitoring
15. geophysical surveys (sonic, downhole and crosshole arrays, seismic reflection, refraction, etc.)	slope stability, undermining
16. underwater inspection	evaluating spillway undermining at toe of dam.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 1 (Continued)

COMPONENT: EMBANKMENT
CONTROL NUMBER: GS-III 15.01.01-1

Special Safety Equipment

Special safety equipment needed for the Level III inspection of the embankment dam are listed in the standards developed for the Standard Inspection of Embankment Dams.

Approved safety life vests must be worn by all inspection personnel when using boats for inspection purposes or when walking across high spillway crests.
Special Instructions

Review as-built and design drawings of structure.

Special Tools and Equipment

Equipment designated in Level I inspections
Survey Level and rod
Navigable boat with approved life preservers
Industry required testing equipment needed to perform the advanced investigation method chosen

Recommended Inspection Frequency

Embankment - as needed basis

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 1 (Continued)

COMPONENT: EMBANKMENT
CONTROL NUMBER: GS-III 15.01.01-1

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993

2. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982

3. EM 1110-2-1902, Stability of Earth and Rock-Fill Dams, April 1, 1970, Includes Change 1

4. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977

5. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974

6. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983

7. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987

8. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987

9. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987

10. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 2

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.01.02-2

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of observable defects recorded in Level I or Level II defect observations of the intake/outlet works.

Whereas the purpose of the Level I and II inspections was to record the observable defects at readily accessible components of the intake/outlet works, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam and the intake/outlet works.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multi-disciplined team of engineers experienced in the design and construction of embankment dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing defect condition or to require continued monitoring of existing deficiency conditions at the intake/outlet works.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III inspection. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Embankment Dams.

For entry into any intake/outlet works structure, operation of any gate facility, or inspection work item performed by boat, the inspection team shall consists of a minimum of two personnel. Any person entering the intake/outlet works structure must have a safety rope and protective harness, and other safety equipment or measures as required by OSHA and all other agencies having jurisdiction.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 2 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.01.02-2

Inspection Actions

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

2. Perform inspection of the pertinent component where observed defects that triggered a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimates for required maintenance or remedial repair measures, if applicable.

Level III advanced test and inspection methods may be required for many different Level I and II defect conditions observed in an intake/outlet work system. Level III advanced test or inspection methods and associated observed defects include, but are not limited to the following:

Advanced Test or Inspection Method	Applicable Observed Defects
1. dye testing	seepage
2. soil borings	undermining, erosion
3. infrared thermography	voids, seepage, poor drainage

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 2 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.01.02-2

Advanced Test or Inspection Method	Applicable Observed Defects
4. ground probing radar	voids
5. flow measurement readings	seepage, leakage
6. geophysical surveys (sonic, downhole and crosshole arrays, seismic reflection, refraction, etc.)	undermining
7. underwater inspection	closing intake structure, inspection of intake structure, evaluating undermining conditions

Special Tools and Equipment

1. Equipment designated in Level I inspections
2. Survey Level and rod
3. Navigable boat with approved life preservers
4. Standard testing equipment required to perform the non-standard test or investigation method

Special Instructions

Review as-built and design drawings of structure.

Special Safety Equipment

Special safety equipment needed for the Level III inspection of an intake/outlet works are listed in the standards developed for the Standard Inspection of Embankment Dams.

Entry into an intake/outlet works structure or conduit requires the use of a protective harness with attached safety rope.

Approved safety life vests must be worn by all inspection personnel when using boats for inspection purposes or when walking across high spillway crests.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 2 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.01.02-2

Recommended Inspection Frequency

Intake/Outlet Works - as needed basis

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993

2. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982

3. EM 1110-2-1902, Stability of Earth and Rock-Fill Dams, April 1, 1970, Includes Change 1

4. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977

5. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974

6. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983

7. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987

8. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987

9. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987

10. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency FEMA 145, August 1987

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 3**

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.01.02-3

Application

This guide has been prepared to identify the purpose of a Level III inspection of gate structure operations at the intake/outlet works.

The results of the Level III inspection can be used to trigger necessary repair or remedial measure activities.

Special Safety Requirements

Operating the intake/outlet works gate will temporarily affect the downstream environment of the dam. Inspection of gate operations must be performed only after prior notification of the Facility Manager or person responsible for the dam structure, and the inspection personnel must check in with the above personnel upon completion of the inspection process.

Inspection of gate operations requires a minimum of two personnel at the gate control system site. The second person should be one who is completely familiar with the operation of the gate structure and actually operates the gate during the inspection.

Inspection Action

1. Two personnel present at the gate control system site.

2. Review operating instructions for the gate.

3. Partially open the gate (mechanical or electrical operated) by appropriate controlling of the gate control system. Allow any debris caught by the gate to be washed through the intake/outlet works system.

4. Open the gate to the "full open" position unless it is necessary to limit gate travel because of low reservoir level. Allow water to pass through the intake/outlet works system and clear any debris from the outlet conduit or stilling basin. Observe water flow exiting the outlet conduit. The gate should be left fully open for no longer than 60 seconds.

5. Close the gate structure completely. Observe exit of outlet conduit for any continued flow. Notify the Facility Manager immediately if unable to close the gate.

** *This Guide Sheet is triggered by conditions beyond the inspection process such as time, age or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 3 (Continued)**

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.01.02-3

Special Tools and Equipment Requirements

Equipment designated for use in gate operations

Special Safety Equipment

No special safety requirements are needed for the Level III inspection of intake/outlet work gate operations beyond the requirements listed in the standards developed for the Standard Inspection of Embankment Dams.

Recommended Inspection Frequency

Gate Operations, Intake/Outlet Works - 1 year intervals

References

1. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982.

2. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

3. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

4. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

5. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

6. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

7. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

8. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA, August 1987.

** *This Guide Sheet is triggered by conditions beyond the inspection process such as time, age or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 4

COMPONENT: SPILLWAY
CONTROL NUMBER: GS-III 15.01.03-5

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of observable defects recorded in Level I or Level II defect observations of the spillway.

Whereas the purpose of the Level I and II inspections was to record the observable defects at readily accessible components of the spillway, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam and the spillway.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multidisciplined team of engineers experienced in the design and construction of embankment dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing defect condition or to require continued monitoring of existing deficiency conditions at the spillway.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III inspection. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Embankment Dams.

For inspection work performed by boat, the inspection team shall consist of a minimum of two personnel.

Inspection Action

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 4 (Continued)

COMPONENT: SPILLWAY
CONTROL NUMBER: GS-III 15.01.03-4

Inspection Action (Continued)

2. Perform inspection of the pertinent component where observed defects that triggered a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimates for required maintenance or remedial repair measures, if applicable.

Level III advanced test and inspection methods may be required for many different Level I and II defect conditions observed in a spillway system. Level III advanced test or inspection methods and associated observed defects include, but are not limited to the following:

Advanced Test or Inspection Method	Applicable Observed Defects
backhoe excavations	soft zones, slope instability, sedimentation accumulation
dye testing	seepage, sinkholes
piezometer installation	slope instability, seepage, wet zones
relief wells	wet zones, seepage
soil borings	slope instability, settlement, undermining, erosion
laboratory tests on soil samples (strength tests, moisture content, consolidation tests, etc.)	slope instability

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 4 (Continued)

COMPONENT: SPILLWAY
CONTROL NUMBER: GS-III 15.01.03-4

Advanced Test or Inspection Method	Applicable Observed Defects
infrared thermography	voids, seepage,
ground probing radar	voids
slope inclinometers	slope stability, measurement monument, structural displacement
slope movement monuments	slope movement, slope stability
crest settlement monuments	crest settlement
erosion survey monuments	extensive or rapidly progressing erosion in downstream channels,
flow measurement readings	seepage, leakage
survey measurements	existing drawings do not match field observations, baseline for erosion monitoring
geophysical surveys (sonic, downhole and crosshole arrays, seismic reflection, refraction, etc.)	slope stability, undermining
underwater inspection	evaluating spillway undermining.

Special Instructions

Review as-built and design drawings of structure.

Special Tools and Equipment

Equipment designated in Level I inspections
Survey Level and rod
Standard testing equipment required to perform the non-standard test or investigation method

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 4 (Continued)

COMPONENT: SPILLWAY
CONTROL NUMBER: GS-III 15.01.03-4

Special Safety Equipment

Special safety equipment needed for the Level III inspection of a spillway are listed in the standards developed for the Standard Inspection of Embankment Dams.

Approved safety life vests must be worn by all inspection personnel when using boats for inspection purposes or when walking across high spillway crests.

Recommended Inspection Frequency

Spillway - as needed basis

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993.

2. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982.

3. EM 1110-2-1902, Stability of Earth and Rock-Fill Dams, April 1, 1970, Includes Change 1.

4. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

5. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

6. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

7. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

8. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

9. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

10. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 5**

COMPONENT: SPILLWAY
CONTROL NUMBER: GS-III 15.01.03-5

Application

This guide has been prepared to identify the purpose of a Level III inspection of the spillway gate operations.

The results of the Level III inspection can be used to trigger a Level III inspection or necessary repair or remedial measure activities.

Special Safety Equipment

No special safety requirements are needed for the Level III inspection of spillway gate operations beyond the requirements listed in the standards developed for the Standard Inspection of Embankment Dams.

Special Safety Requirements

Operating the spillway gate(s) will temporarily affect the downstream environment of the dam. Inspection of gate operations must be performed only after prior notification of the Facility Manager or person responsible for the dam structure, and the inspection personnel must check in with the above personnel upon completion of the inspection process.

Inspection of gate operations requires a minimum of two personnel at the gate control system site. The second person should be one who is completely familiar with the operation of the gate structure and actually operates the gate during the inspection.

1. Two personnel present at the gate control system site.

2. Review operating instructions for the gate.

3. Partially open the gate (mechanical or electrical operated) by appropriate controlling of the gate control system. Allow any debris caught by the gate to be washed over the spillway control structure.

4. Open the gate to the "full open" position unless it is necessary to limit gate travel because of low reservoir level. Allow the water to clear any debris from the spillway gate or stilling basin. Observe water exiting the stilling basin or outlet channel. The gate should be left fully open for not longer than 60 seconds.

5. Close the gate structure completely. Observe closed gate for leakage over the control crest. Notify the Facility Manager immediately if unable to close the gate.

** *This Guide Sheet is triggered by conditions beyond the inspection process such as time, age or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 5 (Continued)**

COMPONENT: SPILLWAY
CONTROL NUMBER: GS-III 15.01.03-5

Special Tools and Equipment Requirements

Equipment designated for use in gate operations

Required Inspection Frequency

Gate Operations, Spillway - 1 year intervals

References

1. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982.

2. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

3. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

4. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

5. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

6. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

7. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

8. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987

** *This Guide Sheet is triggered by conditions beyond the inspection process such as time, age or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 6

COMPONENT: EMERGENCY SPILLWAY
CONTROL NUMBER: GS-III 15.01.04-6

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of observable defects recorded in Level I or Level II defect observations of the emergency spillway.

Whereas the purpose of the Level I and II inspections was to record the observable defects at readily accessible components of the emergency spillway, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam and the emergency spillway.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multidisciplined team of engineers experienced in the design and construction of embankment dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing defect condition or to require continued monitoring of existing deficiency conditions at the emergency spillway.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III inspection. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Embankment Dams.

Inspection Action

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 6 (Continued)

COMPONENT: EMERGENCY SPILLWAY
CONTROL NUMBER: GS-III 15.01.04-6

Inspection Action (Continued)

2. Perform inspection of the pertinent component where observed defects that triggered a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimates for required maintenance or remedial repair measures, if applicable.

Level III advanced test and inspection methods may be required for many different Level I and II defect conditions observed in the emergency spillway system. Level III advanced test or inspection methods and associated observed defects include, but are not limited to the following:

Advanced Test or Inspection Method	Applicable Observed Defects
backhoe excavations	soft zones, slope instability, sedimentation accumulation
dye testing	seepage, sinkholes
piezometer installation	slope instability, seepage, wet zones
relief wells	wet zones, seepage
soil borings	slope instability, settlement, undermining, erosion
laboratory tests on soil samples (strength tests, moisture content, consolidation tests, etc.)	slope instability

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 6 (Continued)

COMPONENT: EMERGENCY SPILLWAY
CONTROL NUMBER: GS-III 15.01.04-6

Advanced Test or Inspection Method	Applicable Observed Defects
infrared thermography	voids, seepage,
ground probing radar	voids
slope inclinometers	slope stability, measurement monument, structural displacement
slope movement monuments	slope movement, slope stability
crest settlement monuments	crest settlement
erosion survey monuments	extensive or rapidly progressing erosion in downstream channels,
flow measurement readings	seepage, leakage
survey measurements	existing drawings do not match field observations, baseline for erosion monitoring
geophysical surveys (sonic, downhole and crosshole arrays, seismic reflection, refraction, etc.)	slope stability, undermining
underwater inspection	evaluating spillway undermining.

Special Instructions

Review as-built and design drawings of structure.

Special Tools and Equipment

Equipment designated in Level I inspections
Survey Level and rod
Standard testing equipment required to perform the non-standard test or investigation method

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 6 (Continued)

COMPONENT: EMERGENCY SPILLWAY
CONTROL NUMBER: GS-III 15.01.04-6

Special Safety Equipment

Special safety equipment needed for the Level III inspection of a spillway are listed in the standards developed for the Standard Inspection of Embankment Dams.

Approved safety life vests must be worn by all inspection personnel when using boats for inspection purposes or when walking across high spillway crests.

Recommended Inspection Frequency

Emergency Spillway - as needed basis

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993

2. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982

3. EM 1110-2-1902, Stability of Earth and Rock-Fill Dams, April 1, 1970, Includes Change 1

4. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977

5. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974

6. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983

7. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 6 (Continued)

COMPONENT: EMERGENCY SPILLWAY
CONTROL NUMBER: GS-III 15.01.04-6

References (Continued)

8. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987

9. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987

10. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 7

COMPONENT: RESERVOIR
CONTROL NUMBER: GS-III 15.01.05-7

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of observable defects recorded in Level I or Level II defect observations of the reservoir.

Whereas the purpose of the Level I and II inspections was to record the observable defects in or surrounding the reservoir, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam and appurtenant works.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multidisciplined team of engineers experienced in the design and construction of embankment dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing defect condition or to require continued monitoring of existing deficiency conditions in or around the reservoir.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III inspection. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Embankment Dams.

Inspection Action

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

2. Perform inspection of the pertinent component where observed defects that triggered a Level III inspection are listed.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 7 (Continued)

COMPONENT: RESERVOIR
CONTROL NUMBER: GS-III 15.01.05-7

Inspection Action (Continued)

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimates for required maintenance or remedial repair measures, if applicable.

Level III advanced test and inspection methods may be required for several Level I and II defect conditions observed in a reservoir system. Level III advanced test or inspection methods and associated observed defects include, but are not limited to the following:

Advanced Test or Inspection Method	Applicable Observed Defects
dye testing	seepage, sinkholes
soil borings	slope instability, settlement, undermining, erosion, sinkholes
laboratory tests on soil samples (strength tests, moisture content, consolidation tests, etc.)	slope instability
infrared thermography	voids, seepage, sinkholes
ground probing radar	voids, sinkholes
slope inclinometers	slope stability, measurement monument,
slope movement monuments	slope movement, slope stability
flow measurement readings	seepage, leakage
underwater inspection	evaluating whirlpool conditions

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 7 (Continued)

COMPONENT: RESERVOIR
CONTROL NUMBER: GS-III 15.01.05-7

Special Instructions

Review as-built and design drawings of structure.

Special Tools & Equipment Requirements

Equipment designated in Level I inspections
Survey Level and rod
Standard testing equipment required to perform the non-standard test or investigation method

Special Safety Equipment

Special safety equipment needed for the Level III inspection of a reservoir are listed in the standards developed for the Standard Inspection of Embankment Dams.

Approved safety life vests must be worn by all inspection personnel when using boats for inspection purposes.

Recommended Inspection Frequency

Reservoir - as needed basis

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 7 (Continued)

COMPONENT: RESERVOIR
CONTROL NUMBER: GS-III 15.01.05-7

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993.

2. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982.

3. EM 1110-2-1902, Stability of Earth and Rock-Fill Dams, April 1, 1970, Includes Change 1

4. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

5. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

6. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

7. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

8. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

9. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

10. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 8

COMPONENT: DOWNSTREAM CHANNEL
CONTROL NUMBER: GS-III 15.01.06-8

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of defects recorded in Level I or Level II defect observations of the downstream channel.

Whereas the purpose of the Level I inspection of the downstream channel was to record the observable defects within a 1/4 to 1/2 mile distance downstream of the dam, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multidisciplined team of engineers experienced in the design and construction of embankment dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing deficiency conditions or to require continued monitoring of existing deficiency conditions along the downstream channel.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III test and inspection method. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Embankment Dams.

Inspection Action

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 8 (Continued)

COMPONENT: DOWNSTREAM CHANNEL
CONTROL NUMBER: GS-III 15.01.06-8

Inspection Action

2. Perform inspection of the pertinent components where observed defects that triggered a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance, or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimate for required maintenance or remedial repair measures, as applicable.

Level III advanced inspection methods may be required for several different Level I defect conditions observed along the downstream channel. Level III advanced test or inspection methods and associated observed defects for a downstream channel include, but are not limited to the following:

Advanced Test or Inspection Method	Applicable Observed Defects
1. backhoe excavations	soft zones, slope instability, sedimentation accumulation
2. dye testing	seepage
3. piezometer installation	slope instability, seepage, wet zones
4. relief wells	wet zones, seepage
5. soil borings	slope instability, erosion
6. laboratory tests on soil samples (strength tests, moisture content, consolidation tests, etc.)	slope instability

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 8 (Continued)

COMPONENT: DOWNSTREAM CHANNEL
CONTROL NUMBER: GS-III 15.01.06-8

Advanced Test or Inspection Method	Applicable Observed Defects
7. infrared thermography	voids, sinkholes, seepage, poor drainage
8. ground probing radar	voids
9. slope inclinometers	slope stability
10. slope movement monuments	slope movement, slope stability
11. erosion survey monuments	extensive or rapidly progressing erosion in downstream channels
12. flow measurement readings	seepage, leakage

Special Instructions

Review as-built and design drawings of structure.

Special Tools and Equipment

Equipment designated in Level I inspections
Survey Level and rod
Navigable boat with approved life preservers
Industry required testing equipment needed to perform the advanced investigation method chosen

Special Safety Equipment

Special safety equipment needed for the Level III inspection of the downstream channel are listed in the standards developed for the Standard Inspection of Embankment Dams.

Recommended Inspection Frequency

Downstream Channel - as needed basis.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 8 (Continued)

COMPONENT: DOWNSTREAM CHANNEL
CONTROL NUMBER: GS-III 15.01.06-8

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993.

2. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982.

3. EM 1110-2-1902, Stability of Earth and Rock-Fill Dams, April 1, 1970, Includes Change 1.

4. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

5. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

6. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

7. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

8. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

9. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

10. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987,

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 9

COMPONENT: ABUTMENTS
CONTROL NUMBER: GS-III 15.01.07-9

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of defects recorded in Level I or Level II defect observations of the abutments of an embankment dam.

Whereas the purpose of the Level I inspection was to record the observable defects at the dam abutments, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam and it's appurtenant works.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multidisciplined team of engineers experienced in the design and construction of embankment dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing deficiency conditions or to require continued monitoring of existing deficiency conditions at the abutments.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III test and inspection method. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Equipment

Special safety equipment needed for the Level III inspection of the abutments are listed in the standards developed for the Standard Inspection of Embankment Dams.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Embankment Dams.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 9 (Continued)

COMPONENT: ABUTMENTS
CONTROL NUMBER: GS-III 15.01.07-9

Inspection Action

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

2. Perform inspection of the pertinent components where observed defects that triggered a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance, or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimate for required maintenance or remedial repair measures, as applicable.

Level III advanced inspection methods may be required for several Level I and Level II defect conditions observed at an embankment dam site. Level III advanced test or inspection methods and associated observed defects for abutments include, but are not limited to the following:

Advanced Test or Inspection Method	Applicable Observed Defects
1. backhoe excavations	soft zones, slope instability,
2. dye testing	seepage
3. piezometer installation	slope instability, seepage, wet zones
4. relief wells	wet zones, clogged toe drains, seepage

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 9 (Continued)

COMPONENT: ABUTMENTS
CONTROL NUMBER: GS-III 15.01.07-9

Advanced Test or Inspection Method	Applicable Observed Defects (Continued)
5. soil borings	slope instability, erosion
6. laboratory tests on soil samples (strength tests, moisture content, consolidation tests, etc.)	slope instability
7. infrared thermography	voids, sinkholes, seepage
8. ground probing radar	voids
9. slope inclinometers	slope stability
10. slope movement monuments	slope movement, slope stability
11. erosion survey monuments	extensive or rapidly progressing erosion along abutments
12. flow measurement readings	seepage, leakage
13. geophysical surveys (sonic, downhole and crosshole arrays, seismic reflection, refraction, etc.)	slope stability

Special Instructions

Review as-built and design drawings of structure.

Special Tools & Equipment Requirements

Equipment designated in Level I inspections
Survey Level and rod
Navigable boat with approved life preservers
Industry required testing equipment needed to perform the advanced investigation method chosen

Recommended Inspection Frequency

Abutments - as needed basis

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 9 (Continued)

COMPONENT: ABUTMENTS
CONTROL NUMBER: GS-III 15.01.07-9

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993.

2. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982.

3. EM 1110-2-1902, Stability of Earth and Rock-Fill Dams, April 1, 1970, Includes Change 1.

4. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

5. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

6. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

7. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

8. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

9. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

10. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987.,

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 10**

COMPONENT: POWER STRUCTURE
CONTROL NUMBER: GS-III 15.01.08-10

Application

This guide has been prepared to identify the purpose of a Level III inspection of gate structure operations of the Power Structure.

The results of the Level III inspection can be used to trigger necessary repair or remedial measure activities.

Special Safety Requirements

Operating the power structure gate will temporarily affect the downstream environment of the dam. Inspection of gate operations must be performed only after prior notification of the Facility Manager or person responsible for the dam and power structure, and the inspection personnel must check in with the above personnel upon completion of the inspection process.

Inspection of gate operations requires a minimum of two personnel at the gate control system site. The second person should be one who is completely familiar with the operation of the gate structure and actually operates the gate during the inspection.

Inspection Action

1. Two personnel present at the gate control system site.
2. Review operating instructions for the gate.
3. Partially open the gate (mechanical or electrical operated) by appropriate controlling of the gate control system.
4. Open the gate to the "full open" position unless it is necessary to limit power structure gate travel because of low reservoir level. Allow water to pass through the power structure gate system and clear any debris from the tail race. Observe water flow exiting the tail race. The gate should be left fully open for no longer than 60 seconds.
5. Close the gate structure completely. Observe tail race for any continued flow. Notify the Facility Manager immediately if unable to close the gate.

** *This Guide Sheet is triggered by conditions beyond the inspection process such as time, age or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 10 (Continued)**

COMPONENT: POWER STRUCTURE
CONTROL NUMBER: GS-II 15.01.08-10

Special Tools and Equipment Requirements

Equipment designated for use in gate operations

Special Safety Equipment

No special safety requirements are needed for the Level III inspection of intake/outlet work gate operations beyond the requirements listed in the standards developed for the Standard Inspection of Embankment Dams.

Recommended Inspection Frequency

Gate Operations, Intake/Outlet Works - 1 year intervals

References

1. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982.

2. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

3. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

4. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

5. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

6. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

7. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

** *This Guide Sheet is triggered by conditions beyond the inspection process such as time, age or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 11

COMPONENT: POWER STRUCTURES
CONTROL NUMBER: GS-III 15.01.08-11

Application

This guide has been prepared to identify the purpose of selection of a Level III Key 11 during inspection of power structures during a Level I embankment dam inspection.

The purpose of the Level I inspection of the power structure is to identify defects which are detrimental to the safe operation or structural integrity of the dam. It is not intended that inspection of the power structure by a Level I embankment dam inspector should be performed in lieu of a Level I inspection of the building structure itself or as an operating power facility. These inspections must be performed by inspectors experienced in the design and operation of such facilities.

Selection of a Level III Key 11 identifies that existing conditions that affect the embankment dam are such that performance of a Power Structures inspection should be performed by appropriate inspection personnel.

Special Safety Requirements

Special safety requirements are as set forth in the written standards for Building Substructure, Building Superstructure, Building Exterior, Building Electrical, an electrical Distribution.

Inspection Items

Inspection items shall be as set forth in the written standards for Building Substructure, Building Superstructure, Building Exterior, Building Electrical, and Electrical Distribution.

Special Tools and Equipment Requirements

Special tools and equipment requirements shall be as set forth in the written standards for Building Substructure, Building Superstructure, Building Exterior, Building Electrical, and Electrical Distribution.

Special Safety Equipment

Special safety requirements required for a Level I inspection of a power structure facility is found in the written standards for Building Superstructure, Building Exterior, Building Electrical, and Electrical Distribution.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 11 (Continued)

COMPONENT: POWER STRUCTURES
CONTROL NUMBER: GS-III 15.01.08-11

Recommended Inspection Frequency

Power Structures - as needed basis; inspection frequency as required for Buildings-Substructure; Buildings-Superstructure; Building Exterior; Building-Electrical; Electrical Distribution; and Tunnels

References

See written standards for Building Substructure, Building Superstructure, Building Exterior, Building Electrical, and Electrical Distribution.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 12

COMPONENT: ACCESS ROAD
CONTROL NUMBER: GS-III 15.01.09-12

Application

This guide has been prepared to identify the Level III Key 12 during a Level I embankment dam inspection.

Level I embankment dam inspection includes observing the condition of access roads or dam related bridges including pavement, drainage ditches, and bridge structure for access roads located along the crest of the embankment dam or where bridging crosses the downstream channel. The purpose of the Level I embankment dam inspection is to ensure that the access roadway is clear for emergency vehicular traffic; to observe if drainage ditches along the sides of the access roadway are free of debris and show no signs of slope instability which encroach on the access road; and to observe general bridge conditions to ensure that passage is achievable.

It is not intended that inspection of the pavement or bridges by a Level I embankment dam inspector should be performed in lieu of a Level I inspection of the pavement or bridge structure itself. These inspections must be performed by inspectors experienced in the design and operation of such structures.

Selection of a Level III Key 12 for pavement or for bridges indicates that obvious signs of deterioration were observed and that a Level I inspection should be performed to accurately measure and identify those conditions by appropriate inspection personnel.

Special Safety Requirements

Special safety requirements are as set forth in the written standards for bridges and pavements.

Inspection Items

Inspection items shall be as set forth in the written standards for bridges and pavements.

Special Tools and Equipment Requirements

Special tools and equipment requirements shall be as set forth in the written standards for bridges and pavements.

Special Safety Equipment

Special safety requirements required for a Level I inspection of bridges and access roads are found in the written standards for bridges and pavements, respectively.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 12 (Continued)

COMPONENT: ACCESS ROAD
CONTROL NUMBER: GS-III 15.01.09-12

Recommended Inspection Frequency

Access Road - as needed basis; inspection frequency as required for Bridges and Pavements/Improved Surfaces

References

See written standards for bridges and pavements.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY 13*

SUBSYSTEM: EMBANKMENT DAM AND APPURTENANT WORKS
CONTROL NUMBER: GS-III 15.01-13*

Application

This guide has been prepared to identify the purpose of a regularly scheduled Level III inspection of embankment dams and appurtenant structures.

Whereas the purpose of the Level I inspection was to record the condition of observable defects at readily accessible components of the dam and appurtenant works, the regularly scheduled Level III inspection is performed to provide a thorough systematic evaluation of the physical condition of the dam and all appurtenant works, and an assessment of the safety and stability of the project structures.

The Level III inspection also includes inspection of sections of the intake/outlet works which may require dewatering or work performed by others prior to actual inspection, and making a visual inspection of the floodplain downstream of the dam to determine the existing land uses occupying the 100-year floodplain.

This type of Level III inspection should be performed on a regularly scheduled basis. The inspection should be performed by an engineer or multidisciplined team of engineers experienced in the design and construction of embankment dams.

The written standards developed for Level I inspection can be used as a guide or outline to be followed during the regularly scheduled Level III inspection. The primary difference between the two types of inspections is that an assessment of observed condition with respect to degree of severity and to the stability and safety of the dam is made and an assessment can be made to indicate which maintenance or remedial measure work is the most important to be completed for the particular project site.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy to correct existing deficiency conditions or result in continued monitoring of existing conditions of the embankment dam and appurtenant works.

Special Safety Equipment

Special safety equipment needed for the engineering inspection of components of an embankment dam and appurtenant works are listed in the standards developed for the Standard Inspection of Embankment Dams.

Entry into an intake/outlet works structure or conduit require the use of a protective harness with attached safety rope.

** This Guide Sheet is not referenced by a Key, but may be "triggered" by conditions beyond the inspection process such as time, age, or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY 13* (Continued)

SUBSYSTEM: EMBANKMENT DAM AND APPURTENANT WORKS
CONTROL NUMBER: GS-III 15.01-13*

Approved safety life vests must be worn by all inspection personnel when using boats for inspection purposes or when walking across high spillway crests.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for Standard Inspection of Embankment Dams.

For entry into any intake/outlet works structure, operation of any gate facility, or inspection work item performed by boat, the inspection team shall consists of a minimum of two personnel. Any person entering the intake/outlet works structure must have a safety rope and protective harness, and other safety equipment or measures as required by OSHA and all other agencies having jurisdiction.

Inspection Action

1. Prior to performing the field inspection, review all past records concerning the dam if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

2. Perform inspection of all pertinent components listed in the written standards for a Level I inspection of an embankment dam and appurtenant works.

3. Inspect any components of the intake/outlet works which require dewatering, entrance into a vertical drop shaft or intake/outlet conduit, or work to be performed by others prior to gaining access to the structure(s).

4. Inspect the floodplain downstream of the dam and determine any changes in the existing land uses occupying the 100-year floodplain.

5. Identify whether particular observed defects need to be further investigated per non-standard test or inspection methods as set forth in GS-III 15.01.01-1 through GS-III 15.01.07-1, or if continued observation is appropriate. Engineer(s) to identify and plan appropriate non-standard test or inspection method and supervise performance of the inspection when applicable.

** This Guide Sheet is not referenced by a Key, but may be "triggered" by conditions beyond the inspection process such as time, age, or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY 13* (Continued)

SUBSYSTEM: EMBANKMENT DAM AND APPURTENANT WORKS
CONTROL NUMBER: GS-III 15.01-13*

Inspection Action (Continued)

7. Make an assessment of the importance of individual defects observed at the dam site. Indicate priorities for any required maintenance, additional investigations, and/or remedial measure work.

8. Assess the stability and safety of the dam.

9. Prepare cost estimates for advanced test or inspection methods to determine the cause and extent of observable defect(s) which may impact the stability of the dam.

10. Prepare cost estimates for required maintenance or remedial repair measures, as applicable.

Special Tools and Equipment Requirements

Equipment designated in Level I inspections
Survey Level and rod
Navigable boat with approved life preservers
Standard testing equipment required to perform the non-standard test or investigation method
Protective harness with safety rope

Recommended Inspection Frequency

Regularly Scheduled Level III Inspection - 3 year intervals

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993.

2. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982.

3. EM 1110-2-1902, Stability of Earth and Rock-Fill Dams, April 1, 1970, Includes Change 1.

** This Guide Sheet is not referenced by a Key, but may be "triggered" by conditions beyond the inspection process such as time, age, or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY 13* (Continued)

SUBSYSTEM: EMBANKMENT DAM AND APPURTENANT WORKS
CONTROL NUMBER: GS-III 15.01-13*

References (Continued)

4. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

5. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

6. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

7. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

8. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

9. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

10. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987

** This Guide Sheet is not referenced by a Key, but may be "triggered" by conditions beyond the inspection process such as time, age, or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 14

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.01.02-14

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of observable defects recorded in Level I or Level II defect observations of the intake/outlet works.

Whereas the purpose of the Level I and II inspections was to record the observable defects at readily accessible components of the intake/outlet works, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam and the intake/outlet works.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multi-disciplined team of engineers experienced in the design and construction of embankment dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing defect condition or to require continued monitoring of existing deficiency conditions at the intake/outlet works.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III inspection. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Embankment Dams.

For entry into any intake/outlet works structure, operation of any gate facility, or inspection work item performed by boat, the inspection team shall consists of a minimum of two personnel. Any person entering the intake/outlet works structure must have a safety rope and protective harness, and other safety equipment or measures as required by OSHA and all other agencies having jurisdiction.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 14 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.01.02-14

Inspection Actions

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

2. Perform inspection of the pertinent component where observed defects that triggered a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimates for required maintenance or remedial repair measures, if applicable.

Level III advanced test and inspection methods may be required for many different Level I and II defect conditions observed in an intake/outlet work system. Level III advanced test or inspection methods and associated observed defects include, but are not limited to the following:

Advanced Test or Inspection Method	Applicable Observed Defects
1. dye testing	seepage
2. soil borings	undermining, erosion
3. infrared thermography	voids, seepage, poor drainage

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 14 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.01.02-14

Advanced Test or Inspection Method	Applicable Observed Defects
4. ground probing radar	voids
5. flow measurement readings	seepage, leakage
6. geophysical surveys (sonic, downhole and crosshole arrays, seismic reflection, refraction, etc.)	undermining
7. underwater inspection	closing intake structure, inspection of intake structure, evaluating undermining conditions

Special Tools and Equipment

1. Equipment designated in Level I inspections
2. Survey Level and rod
3. Navigable boat with approved life preservers
4. Standard testing equipment required to perform the non-standard test or investigation method

Special Instructions

Review as-built and design drawings of structure.

Special Safety Equipment

Special safety equipment needed for the Level III inspection of an intake/outlet works are listed in the standards developed for the Standard Inspection of Embankment Dams.

Entry into an intake/outlet works structure or conduit requires the use of a protective harness with attached safety rope.

Approved safety life vests must be worn by all inspection personnel when using boats for inspection purposes or when walking across high spillway crests.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 14 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.01.02-14

Recommended Inspection Frequency

Intake/Outlet Works - as triggered by Level I inspection observations

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993

2. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982

3. EM 1110-2-1902, Stability of Earth and Rock-Fill Dams, April 1, 1970, Includes Change 1

4. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977

5. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974

6. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983

7. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987

8. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987

9. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987

10. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency FEMA 145, August 1987

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 15

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.01.02-15

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of observable defects recorded in Level I or Level II defect observations of the intake/outlet works.

Whereas the purpose of the Level I and II inspections was to record the observable defects at readily accessible components of the intake/outlet works, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam and the intake/outlet works.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multi-disciplined team of engineers experienced in the design and construction of embankment dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing defect condition or to require continued monitoring of existing deficiency conditions at the intake/outlet works.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III inspection. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Embankment Dams.

For entry into any intake/outlet works structure, operation of any gate facility, or inspection work item performed by boat, the inspection team shall consists of a minimum of two personnel. Any person entering the intake/outlet works structure must have a safety rope and protective harness, and other safety equipment or measures as required by OSHA and all other agencies having jurisdiction.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 15 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.01.02-15

Inspection Actions

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

2. Perform inspection of the pertinent component where observed defects that triggered a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimates for required maintenance or remedial repair measures, if applicable.

Level III advanced test and inspection methods may be required for many different Level I and II defect conditions observed in an intake/outlet work system. Level III advanced test or inspection methods and associated observed defects include, but are not limited to the following:

Advanced Test or Inspection Method	Applicable Observed Defects
1. dye testing	seepage
2. soil borings	undermining, erosion
3. infrared thermography	voids, seepage, poor drainage

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 15 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.01.02-15

Advanced Test or Inspection Method	Applicable Observed Defects
4. ground probing radar	voids
5. flow measurement readings	seepage, leakage
6. geophysical surveys (sonic, downhole and crosshole arrays, seismic reflection, refraction, etc.)	undermining
7. underwater inspection	closing intake structure, inspection of intake structure, evaluating undermining conditions

Special Tools and Equipment

1. Equipment designated in Level I inspections
2. Survey Level and rod
3. Navigable boat with approved life preservers
4. Standard testing equipment required to perform the non-standard test or investigation method

Special Instructions

Review as-built and design drawings of structure.

Special Safety Equipment

Special safety equipment needed for the Level III inspection of an intake/outlet works are listed in the standards developed for the Standard Inspection of Embankment Dams.

Entry into an intake/outlet works structure or conduit requires the use of a protective harness with attached safety rope.

Approved safety life vests must be worn by all inspection personnel when using boats for inspection purposes or when walking across high spillway crests.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 15 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.01.02-15

Recommended Inspection Frequency

Intake/Outlet Works - as triggered by Level I inspection observations

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993

2. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982

3. EM 1110-2-1902, Stability of Earth and Rock-Fill Dams, April 1, 1970, Includes Change 1

4. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977

5. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974

6. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983

7. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987

8. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987

9. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987

10. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency FEMA 145, August 1987

15.02 CONCRETE DAMS

DESCRIPTION

Concrete dams are generally classified as one of three categories: gravity, buttress, or arch. The three classifications are differentiated by the way that forces are distributed into the surrounding valley sides or floor.

A concrete gravity dam is a structure proportioned so that it depends on its own weight to provide the major resistance to the forces exerted upon it. This type of concrete dam is generally constructed of unreinforced blocks of concrete with flexible seals in the joints between the blocks. The most common type of failure associated with gravity dams are overturning or sliding on the foundation. Design of a concrete gravity dam must be developed taking into account the following assumptions: the foundation is capable of resisting the applied forces without overstressing the dam or its foundation; the horizontal forces in the downstream direction must be resisted so that shear failure is not induced in the base of the concrete, at the concrete-rock interface, or in the foundation materials; and uplift pressures must be resisted to prevent overturning of the dam.

Buttress dams are a form of gravity dams with respect to stress distribution. These dams generally consist of a sloping slab of concrete that rests on vertical buttresses. The buttresses must be designed to withstand overturning forces. Due to the relative thinness of this type of dam, excessive deterioration, pitting or spalling of the concrete can significantly decrease the strength of the slab and increase the potential for seepage through the concrete dam structure.

Arch dams are relatively thin structures in comparison to gravity dams where the forces imposed are primarily carried into the abutments. The foundation is only required to carry the weight of the structure. The shape of the dam may resemble a section of a circle or ellipse, or combination of the two. In general, the dam is constructed of a series of relatively thin blocks that are keyed together. Construction joints are either grouted during or after construction, left open, or filled with flexible seals. Construction joints left open after construction are assumed to close under the reservoir load. Possible failure modes in an arch dam include overturning; mass movement of the abutments causing dam failure; excessive abutment movement causing tension cracks in the concrete and subsequent rupture of the dam; and excessive uplift in the foundation which causes overturning or movement of rock blocks in the foundation.

Concrete dams may consist of a combination of a concrete structure with secondary embankment components.

The primary components of concrete dams include the concrete dam structure and foundation; principal spillway; emergency spillway; drawdown facility (intake/outlet works); and abutment areas. Related components of concrete dams which require inspection include the reservoir; downstream channel; power structures; and access road.

15.02 CONCRETE DAMS

SPECIAL TOOL AND EQUIPMENT REQUIREMENTS

No special tools are needed for the Level I and Level II inspection of the concrete dam structure, beyond the requirements listed in the Standard Tools Section and the Special Tools and Equipment Requirements Section for Dams.

If boat access is readily available, (and required for inspection), Level I inspection personnel must wear approved safety life vests for boat travel to gain safe access to inspect intake structures.

If observation of the intake/outlet works requires the structure to be dewatered specifically for the successful performance of the inspection, then the inspection will be performed as part of the regularly scheduled Level III inspection. It should be noted that entry into inlet or outlet conduits require the use of a protective harness with attached safety rope.

SPECIAL SAFETY REQUIREMENTS

Since the inspection is performed by walking along the crest of the dam structure and steep slopes adjacent to a reservoir or stream channel, the potential for falling into water or down a slope always exists. Inspection must be performed only after prior notification of the Facility Manager or person responsible for the dam structure, and the inspection personnel must check in with the above personnel upon completion of the inspection process.

Inspection of the intake/outlet works and the upstream face of the dam may include observing conditions by boat, if readily available and conditions warrant. If the inspector opts to use a boat, then special safety requirements include the use of a life vest.

Although not required for Level I inspection, any entry into an intake/outlet works structure requires the presence of a minimum of two inspection personnel. Any person entering the intake/outlet works structure must have a safety rope and protective harness, and other safety equipment or measures as required by OSHA and all other agencies having jurisdiction. Inspectors walking across the spillway crest must wear a life preserver where applicable.

Inspection of any power structure built in conjunction with a dam must be performed only after prior notification of the Facility Manager or person responsible for the power structure, and the inspection personnel must check in with the above personnel upon completion of the inspection process. The inspectors must observe all safety requirements posted for work performed inside and around the power structure.

Inspection of any applicable access road may include walking along an access roadway or over a bridge. Passing traffic may be a hazard to the inspectors. The inspection must be performed with the prior approval of the Facility Engineer who will notify the authorities to provide safety measures and safe access, if required.

15.02 CONCRETE DAMS

COMPONENT LIST

- 15.02.01 CONCRETE DAM STRUCTURE
- 15.02.02 ABUTMENTS
- 15.02.03 SPILLWAY
- 15.02.04 EMERGENCY SPILLWAY
- 15.02.05 INTAKE/OUTLET WORKS
- 15.02.06 RESERVOIR
- 15.02.07 DOWNSTREAM CHANNEL
- 15.02.08 POWER STRUCTURES
- 15.02.09 ACCESS ROAD

RELATED SUBSYSTEMS

01	BUILDING SUBSTRUCTURE (all subsystems)
02	BUILDING SUPERSTRUCTURE (all subsystems)
03	BUILDING EXTERIOR (all subsystems)
10	BUILDING ELECTRICAL (all subsystems)
16	BRIDGES (all subsystems)
17	TUNNELS (all subsystems)
19	PAVEMENTS/IMPROVED SURFACES (all subsystems)
29	SITE ELECTRICAL (all subsystems)

STANDARD INSPECTION PROCEDURE

Prior to performing a Level I inspection, the inspector(s) should review existing records such as pre-construction investigation records, design criteria and analysis records, available construction records, and photographs taken during initial construction or subsequent site inspections, preceding inspection reports, notes, and photographs, water levels, movement monument survey records, and other applicable instrumentation records.

Review of existing records and data calculated by the planners should result in the Inspector becoming familiarized with the layout, geometric configuration, and dimensions of the dam well as the historical record of the condition of the dam.

Once the field work commences and prior to the start of the actual recording of observed defect data, it will be necessary for the inspector to establish some measure of stationing along the crest of the dam, along the abutments, and along the intake/outlet works, spillway chute or stilling basin, or other components of the dam as necessary to establish a basis for locating observed defects. Such stationing can match existing stationing shown on existing design or as-built drawings or can be established independently by the inspectors as long as the location of Station 0+00 is recorded.

15.02 CONCRETE DAMS

Inspection of a concrete dam generally involves walking along the crest of the dam structure, abutment slopes and downstream channel slopes looking for concrete deterioration, cracks, leakage, displacement and structural movement, and observing if drainage structures are operational and not clogged. Level I inspection can also include observation of existing conditions of the galleries and/or foundation tunnels if readily accessible. If readily available and a second person is available at the site to assist the inspector, inspection of the upstream face of the dam structure can be performed by boat; otherwise, inspection of the upstream face slope using a boat should be performed as part of the regularly scheduled Level III inspections.

Level I inspections of the abutments should include visual inspection of both the left (looking downstream) and right abutment areas, particularly the groin area of the dam at the embankment - natural ground contact. Observations should be made from the crest of the dam or spillway and also from the top of the abutment slope.

Inspection of the spillway generally involves observing the overflow structure from the downstream side, from the side of the structure, and possibly walking across the control crest. Any gates which can be readily accessed should be inspected for deterioration and leakage.

Inspection of the emergency spillway consists of walking along the approach and outlet channels to observe any debris, erosion, obstructions, vegetation, or sediment which may block or restrict flow to or from the spillway. Inspection also includes observation of existing conditions along the spillway control structure.

Inspection of the intake/outlet works includes noting the physical condition of the mechanical gate control system, an examination of the condition of any exposed surfaces of the structure(s). Inspection of the interior of an intake/outlet works structure is performed during a Level III inspection and requires climbing or crawling into the conduit passing through the dam where applicable or sized appropriately in order to look for deterioration and/or displacement of the pipe and for leakage.

Observation of spillway or intake/outlet work gate operations is a Level III inspection item. Operation of the gate structure(s) should only be performed when a minimum of two personnel are present at the gate control site.

Inspection of the reservoir during a Level I inspection includes determination of reservoir levels and observation of conditions along the reservoir rim looking for indications of erosion, slope instability, or sinkhole development. It is desirable to observe the condition of the reservoir rim during periods of both high and low reservoir levels.

For purposes of the Level I inspection, the downstream channel should be inspected for a distance of 1/4 to 1/2 mile downstream of the existing toe of the dam. Inspection of the downstream channel includes a walk-through to observe that conditions do not exist which could lead to obstruction of flow or pooling of water against the toe of the dam.

15.02 CONCRETE DAMS

A Level I inspection of power structures may be required for purposes of identifying defects which are detrimental to the safe operation or structural integrity of the dam. Such inspection should include observation of the condition of the intake, outlet and penstock structures. Observation of gate structure operations is considered a Level III inspection.

Inspection of the power structure generally involves observing the outside condition of the structure from the shoreline and/or dam, as well as general interior conditions of the plant if accessible at the time of inspection.

Inspection of the structure as an operating power producing facility and as a building structure should be carried out by appropriate inspection personnel in accordance with the standards prepared for Building Foundation, Building Substructure, Building Superstructure, Power Distribution, and Tunnels.

Observation of actual power generating operations is a Level I inspection which should be performed by appropriate electrical and structural inspector personnel.

Inspection of the access road during a Level I concrete dam inspection is limited to observing the roadway and any bridge crossings for access to the dam site, if applicable. Pavement condition should be inspected in accordance with the standards prepared for Pavements/Improved Surfaces and any bridge crossing should be inspected in accordance with the standards for Bridges.

Photo documentation of existing conditions at the time of inspection is essential to creating a historical record of the condition of the dam over time. Photographs should be taken to record the overall (panorama view) condition of the main components of the dam and appurtenant works as well as to record particular observed defects which are of concern. A record of photographs which have been taken can be input into the Data Collection Device by using the photo log option in the Comments screen. In addition, pertinent additional information which is observed during the Level I inspection, such as location or details of a particular observed defect, should be input into the Comments screen of the Data Collection Device.

Help screens have been developed and installed in the Field CAIS program to assist the Inspector during the Level I inspection for dams. Such help screens provide a brief summary of what is required for the inspection of a particular component, as well as listing of potential defects to be looked for during the inspection. Full descriptions of potential defects are presented in Appendix B.

It is the intent of the standard inspection procedure to document the overall condition of the dam and appurtenant works and to obtain an order of magnitude measure of the quantity of observed defects resulting in budget projection of cost to repair or replace. The inspector should not focus on obtaining precise measurements. Due to the large scale of the components comprising a dam and to commonly difficult access conditions along a dam, it is often beneficial to estimate the areal or linear extent of a particular defect instead of spending an excessive amount of time trying to obtain an exact measure. It is acknowledged that estimating the unit of measure quantity is somewhat subjective, but doing so, when appropriate to conditions, will save considerable time during the inspection process. The comment screen should be used to indicate any backup data or assumptions made to indicate how the inspector came up with a particular measure of observed defect if necessary.

15.02 CONCRETE DAMS

COMPONENTS

◆ 15.02.01 CONCRETE DAM STRUCTURE

The concrete dam structure is the primary part of the dam which impounds the water for its intended purposes. The dam structure is constructed of concrete, or masonry materials with or without a concrete face. Types of concrete dams are presented in Section 15.02, Concrete Dams.

Inspection of a concrete dam structure requires observation for defects along the exposed concrete surfaces of the dam, the galleries, and any foundation tunnels. Brief descriptions of these structures follow.

The concrete dam surfaces include the upstream and downstream faces and the crest of the dam. The slope gradients and plan section of the concrete dam structure depend on the type of dam selected, the design of the structure, and the condition of the existing foundation and abutments. The width or thickness of the dam at the crest is dependent on the type of dam and the use of the crest. Details concerning the plan and cross section of the concrete dam structure are found in the design or construction drawings.

Potential deficiencies which can be associated with concrete dam surfaces include widespread superficial deterioration of the concrete; localized zones of highly concentrated surface deterioration; deep cracking of the concrete surfaces; leakage associated with poor condition concrete, open cracks or construction joints; leakage/seepage through the foundation or abutments; structural movement or displacement of the dam structure; development of offsets at construction or monolith joints; or development of unusual movement, cracking or erosion at the toe of the downstream face of the dam.

A gallery is a passageway within the body of a dam or abutment, where applicable. Galleries provide a necessary or convenient means for performing grouting, incorporating drainage facilities, and allowing post-construction of the dam. Galleries may be provided for drainage and inspection, or for access to sluice gate machinery, penstock filling valves, oil lines, electrical outlets, instrumentation requirements, or for other purposes as needed.

A drainage and inspection gallery is usually provided near the upstream face of a concrete dam and just above the foundation. Commonly, vertical formed drain holes 5 or 6 inches in diameter, spaced approximately 5 to 10 feet apart, extend from the gallery to an elevation near the top of the dam. Water collected in the gallery is discharged to tailwater at the downstream toe of the dam. Details concerning the existing galleries at a given dam site can be obtained from the design and construction drawings.

Potential defects which can be observed in galleries include deterioration of the general concrete condition and any associated metalwork; malfunctioning electrical systems; seepage into the galleries; and clogged drains and drainage problems.

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ 15.02.01 CONCRETE DAM STRUCTURE (Continued)

Foundation tunnels through the concrete dam or abutment can include diversion tunnels, outlet works tunnels, power tunnels, drainage tunnels, and gallery and access tunnels. Details concerning any foundation tunnels at a particular dam site can be obtained from the design or construction drawings.

The foundation tunnels may or may not be accessible at the time of the Level I inspection. If the tunnels are not accessible, then inspection should be performed during the regularly scheduled Level III inspection.

The Level I inspection of the foundation tunnels is performed to determine the general condition of the concrete or metal lining of the tunnels, and to observe if a seepage problem exists along the tunnel. Detailed inspections of the tunnel(s) should be performed by appropriate personnel in accordance with the Level III standards for Tunnels.

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Superficial Concrete Deterioration - Concrete Dam Structure:**			
Observation:			
a. Isolated hairline cracks or superficial cracks less than 1/8" wide with no leakage. *** {Severity L}	SF		
b. Spalling, chipped concrete. *** {Severity M}	SF		
c. Deteriorated concrete (cavitation, spalling) with exposed steel reinforcing *** {Severity H}	SF		
Defect:			
*** Localized Spalling and Cracking of Concrete Face - Concrete Dam Structure:**			
Observation:			
a. Isolated hairline cracks or superficial cracks less than 1/8" wide with no leakage. *** {Severity L}	SF		
b. Spalling, chipped concrete. *** {Severity M}	SF		
c. Deteriorated concrete (cavitation, spalling) with exposed steel reinforcing. *** {Severity H}	SF		

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.01 CONCRETE DAM STRUCTURE (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Deep Cracking of Concrete Surfaces - Concrete Dam Structure:**			
Observation:			
a. Isolated deep crack, less than 1/4" in width above water line.	LF		
*** {Severity L}			
b. Isolated deep crack, less than 1/4" in width, downstream slope, no associated seepage.	LF		
*** {Severity L}			
c. Isolated or several unrelated deep cracks, less than 1/2" in width, crest or downstream slope, no associated seepage.	LF		
*** {Severity M}			
d. Isolated deep crack greater than 1/2" in width; multiple or interconnected or radiating cracks, with or without leakage.	LF		1
*** {Severity H}			
e. Isolated or several unrelated deep cracks less than 1/2" in width, upstream face, below highest recorded waterline.	LF		1
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.01 CONCRETE DAM STRUCTURE (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Seepage Through Concrete Dam - Concrete Dam Structure:**			
Observation:			
a. Moist or wet surfaces on concrete, associated with minor cracks or deteriorated concrete.	SF		1
*** {Severity L}			
b. Leakage through cracks, open joints, or differential movement through concrete, or due to plugged drains.	SF		1
*** {Severity M}			
c. Leakage through deep crack(s) or interconnected or radiating cracks, or cracks at waterline.	SF		1
*** {Severity H}			
d. Noticeable increase in leakage through concrete from previous inspection.	SF		1
*** {Severity H}			
e. Leakage through foundation, intersection of dam and abutment, or toe of dam.	SF		1
*** {Severity H}			

Defect:

*** Movement/Settlement of Concrete Dam Structure:**			
Observation:			
a. Movement/settlement less than 1/4".	SF		
*** {Severity L}			
b. Movement/settlement equal to or less than 1".	SF		
*** {Severity M}			
c. Movement/settlement greater than 1".	SF		1
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.01 CONCRETE DAM STRUCTURE (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Construction/Monolith Joints - Concrete Dam Structure:**			
Observation:			
a. Joint separation less than 1/4" wide, no associated leakage.	LF		
*** {Severity L}			
b. Joint separation equal to or less than 1/2" wide, no leakage.	LF		
*** {Severity M}			
c. Joint separation greater than 1/2" open, or any open joint with associated leakage	LF		1
*** {Severity H}			
Defect:			
*** Unusual Movement/Cracking at Toe of Slope - Concrete Dam Structure:**			
Observation:			
a. Single isolated crack at toe of dam.	LF		
*** {Severity L}			
b. More than one unconnected crack.	LF		
*** {Severity M}			
c. Numerous interconnected cracks, or single crack greater than 6" deep, or bulges or slumps in foundation materials at toe of dam.	SF		1
*** {Severity H}			
d. Erosion and/or loss of foundation at toe.	SF		1
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.01 CONCRETE DAM STRUCTURE (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Railing (on crest) - Concrete Dam Structure:**			
Observation:			
a. Rusting or superficial deterioration of railing.	LF		
*** {Severity L}			
b. Loose, broken or severely deteriorated rails.	LF		
*** {Severity M}			
c. Rails missing.	LF		
*** {Severity H}			
d. Posts missing.	EA		
*** {Severity H}			
Defect:			
*** Lighting (on crest) - Concrete Dam Structure:**			
Observation:			
a. Dim and insufficient lighting, light needs repair/ replacement.	EA		
*** {Severity L}			
b. Lights broken or missing from poles.	EA		
*** {Severity H}			
Defect:			
*** Superficial Concrete Deterioration - Galleries (If applicable):**			
Observation:			
a. Isolated hairline cracks or superficial cracks less than 1/8" wide with no leakage.	LF		
*** {Severity L}			
b. Spalling, chipped concrete.	SF		
*** {Severity M}			
c. Deteriorated concrete (cavitation, spalling) with exposed steel reinforcing	SF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.01 CONCRETE DAM STRUCTURE (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Localized Spalling and Cracking of Concrete Face - Galleries (If applicable):**			
Observation:			
a. Isolated hairline cracks or superficial cracks less than 1/8" wide with no leakage.	LF		
*** {Severity L}			
b. Spalling, chipped concrete.	SF		
*** {Severity M}			
c. Deteriorated concrete (cavitation, spalling) with exposed steel reinforcing.	SF		
*** {Severity H}			
Defect:			
*** Deep Cracking of Concrete Surfaces - Galleries (if applicable):**			
Observation:			
a. Isolated deep crack, less than 1/4" in width, above water line, no associated seepage.	LF		
*** {Severity L}			
b. Isolated or several unrelated deep cracks, less than 1/2" in width, above water line, no associated seepage.	LF		
*** {Severity M}			
c. Isolated deep crack greater than 1/2" in width, multiple interconnected or radiating cracks, with or without leakage.	LF		1
*** {Severity H}			
Defect:			
*** Metalwork (if applicable) - Galleries (if applicable):**			
Observation:			
a. Surface rusting, less than 25% of exposed metal.	SF		
*** {Severity L}			
b. Rusting or pitted surface, less than 50% of exposed metal.	SF		
*** {Severity M}			
c. Rusting or pitted surface greater than 50% of exposed metal, or voids or open seams.	SF		1
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.01 CONCRETE DAM STRUCTURE (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Electrical Systems/Lights - Galleries (If applicable):**			
Observation:			
a. Electrical systems/lights not working	EA		1
*** {Severity H}			
Defect:			
*** Seepage into Galleries (If applicable):**			
Observation:			
a. Moist or wet surfaces on concrete, associated with minor cracks or deteriorated concrete, (not associated with drainage through gallery).	SF		
*** {Severity L}			
b. Leakage through cracks, open joints, or differential movement through concrete (not associated with drainage through gallery).	SF		1
*** {Severity M}			
c. Leakage through deep crack(s) or interconnected or radiating cracks (not associated with drainage through gallery).	SF		1
*** {Severity H}			
Defect:			
*** Drains/Drainage - Galleries (If applicable):**			
Observation:			
a. Damaged or clogged drains.	EA		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.01 CONCRETE DAM STRUCTURE (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** General Concrete Condition (if applicable) - Foundation Tunnels:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Cracked concrete structure.	SF		
*** {Severity M}			
c. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			
Defect:			
*** Metalwork (if applicable) - Foundation Tunnels:**			
Observation:			
a. Surface rusting, less than 25% of exposed metal.	SF		
*** {Severity L}			
b. Rusting or pitted surface, less than 50% of exposed metal.	SF		
*** {Severity M}			
c. Rusting or pitted surface greater than 50% of exposed metal, or voids or open seams	SF		
*** {Severity H}			
Defect:			
*** Seepage in Foundation Tunnel (If applicable):**			
Observation:			
a. Observed wall dampness.	SF		
*** {Severity L}			
b. Observed seepage.	SF		1
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ 15.02.02 ABUTMENTS

Abutment areas are the contact points between the ends of the concrete dam or spillway and the natural ground. The natural ground at these locations can be comprised of soil or rock. These areas should be closely and frequently inspected for any signs of seepage, cracks or erosion. Observation of any of these conditions should prompt an engineering inspection so that an assessment of the safety of the dam can be determined and a baseline measurement can be established to assist in identifying whether the problem is intensifying.

Potential defects to be looking for include erosion of the abutments, seepage, and instability of the abutments due to landslides, surface sloughing, soil creep, rock falls, surface cracking, or surface rupture.

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Slope Stability - Left Abutment:**			
Observation:			
a. Soil creep.	SF		
*** {Severity L}			
b. Surface sloughing.	SF		
*** {Severity M}			
c. Rock falls.	SF		
*** {Severity M}			
d. Surface cracking.	SF		
*** {Severity M}			
e. Surface rupture.	SF		2
*** {Severity H}			
f. Landslides.	SF		2
*** {Severity H}			
Defect:			
*** Surface Erosion - Left Abutment:**			
Observation:			
a. Single isolated erosion less than 6" deep, not compromising the stability of the abutment.	SF		
*** {Severity L}			
b. Occasional erosion areas, less than 12" deep.	SF		2
*** {Severity M}			
c. Erosion greater than or equal to 12" deep, or erosion 6" to 12" deep occurring greater than 3 times/20 LF.	SF		2
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.02 ABUTMENTS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Seepage - Left Abutment:**			
Observation:			
a. Damp or wet spots.	SF		
*** {Severity M}			
b. Observed seepage.	SF		2
*** {Severity H}			
Defect:			
*** Slope Stability - Right Abutment:**			
Observation:			
a. Soil creep.	SF		
*** {Severity L}			
b. Surface sloughing.	SF		
*** {Severity M}			
c. Rock falls.	SF		
*** {Severity M}			
d. Surface cracking.	SF		
*** {Severity M}			
e. Surface rupture.	SF		2
*** {Severity H}			
f. Landslides.	SF		2
*** {Severity H}			
Defect:			
*** Surface Erosion - Right Abutment:**			
Observation:			
a. Single isolated erosion less than 6" deep, not compromising the stability of the abutment.	SF		
*** {Severity L}			
b. Occasional erosion areas, less than 12" deep.	SF		2
*** {Severity M}			
c. Erosion greater than 12" deep or erosion 6" to 12" deep occurring greater than 3 times/20 LF.	SF		2
*** {Severity H}			
Defect:			
*** Seepage - Right Abutment:**			
Observation:			
a. Damp or wet spots.	SF		
*** {Severity M}			
b. Observed seepage.	SF		2
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ 15.02.03 SPILLWAY

The principal spillway is a structure which passes normal amounts of water past the dam in a safe and non-erosive manner. This spillway can be either, 1) a metal or concrete pipe through the dam incorporating a stand pipe or rise intake structure (as explained in WBS 15.02.05), or 2) a concrete overflow type structure which may or may not be gated. Inspection of a primary spillway requires observation for defects at the approach channel, control structure, gates, chutes, stilling basin, and outlet channel. Brief descriptions of these structures follow.

Depending on the design of the principal spillway, an overflow structure can have an approach channel which is an arm of the reservoir, particularly when the spillway is placed through an abutment or saddle in the topography. In cases where a concrete dam with an overflow spillway is constructed as part of the dam, an approach channel does not exist. Whether an approach channel exists or not for a particular dam can be readily identified in the field.

Potential defects which can be observed in a spillway approach channel include extensive vegetation growth or debris accumulation which obstructs flow through the channel; unstable channel side slopes or large scale stability problems occurring above the immediate channel; lack or displacement of slope protection measures; and erosion of the channel bottom to undermine the control structure.

The control structure regulates and controls the outflow from the reservoir. The control structure may consist of a sill, weir, orifice, tube, or pipe. Typically, the control structure consists of a concrete overflow structure built into the dam. Details concerning the type and length of the spillway can be obtained from the construction drawings or can be observed and measured in the field.

Potential defects which can be observed in the control structures include deterioration of the concrete surface of the spillway apron, crest and walls; and movement, settlement, separation or cracking of the spillway apron, crest and walls. Potential defects associated with a pipe extending through the dam are covered in the Standard for Intake/Outlet Works.

The spillway control structure may or may not contain gates. Details concerning the gates at a particular site can be obtained from the design or construction drawings.

Potential defects which can be observed in the gate structures include deterioration of the overall condition and protective coating of the gate; leakage around or under the gate when the gate is closed; malfunctioning gate operating equipment; or missing emergency machinery to operate the gate.

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ 15.02.03 SPILLWAY (Continued)

A spillway chute is a discharge channel extending from the crest or toe of the control structure to the stilling basin or terminal structure. In most instances, flow released through the control structure is conveyed to the streambed below the dam in a discharge channel. Exceptions include cases where the discharge falls freely from an arch dam crest or where flow is discharged directly along the abutment hillside. Details concerning the chute can be obtained from the construction drawings. The floor of the chute may or may not be visible depending on the amount of water flowing over the spillway.

Potential defects which can be observed in the spillway chute include accumulation of debris which can obstruct flow; general concrete deterioration of the walls or floor; movement, settlement, displacement or cracking of the chute floor, walls, and construction joints; seepage into the chute; or erosion or undermining of materials beneath the chute.

The stilling basin is used to decrease the flow velocity of water spilling over the spillway crest and into the outlet channel in order to prevent or minimize scour or erosion of the toe of the dam or damage to adjacent structures. Depending on the design of the spillway and condition of the downstream channel, the stilling basin can be a separate structure or a pool within the downstream or outlet channel. Details and dimensions of the stilling basin can be obtained from the construction drawings or can be determined in the field.

Potential defects which can be observed at the stilling basin include debris accumulation which limits the effectiveness of the spillway; movement, settlement, or cracking of the stilling basin walls or construction joints; loss of soil behind the stilling basin walls; movement, cracking or displacement of the stilling basin floor; or erosion or undermining of soil or rock beneath the floor slab.

Flow from the spillway exits into the main downstream channel or into a separate outlet channel which converges with the main channel at some distance downstream of the dam. The outlet channel dimensions and its need for protection by lining or riprap will depend on the influences of scour in the tailwater. Actual condition of the outlet channel will be readily observable in the field.

Potential defects which can be observed in the outlet channel include heavy vegetation growth or debris accumulation which obstructs flow through the outlet channel; missing or displaced slope protection measures; or channel slope instability which could lead to impoundment or obstruction of the outlet channel.

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Vegetation/Debris Accumulation - Approach Channel (if applicable):**			
Observation:			
a. Channel less than 25% blocked by debris. *** {Severity L}	SF		
b. Channel 25% to 75% blocked by debris. *** {Severity M}	SF		
c. Channel greater than 75% blocked by debris. *** {Severity H}	SF		
Defect:			
*** Channel Side Slope Stability - Approach Channel (if applicable):**			
Observation:			
a. Soil creep. *** {Severity L}	SF		
b. Surface sloughing. *** {Severity M}	SF		
c. Rock falls. *** {Severity M}	SF		
d. Surface cracking. *** {Severity M}	SF		
e. Surface rupture. *** {Severity H}	SF		3
f. Landslides. *** {Severity H}	SF		3

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Slope Movement Above Channel - Approach Channel (if applicable):**			
Observation:			
a. Soil creep.	SF		
*** {Severity L}			
b. Surface sloughing.	SF		
*** {Severity M}			
c. Rock falls.	SF		
*** {Severity M}			
d. Surface cracking.	SF		
*** {Severity M}			
e. Surface rupture.	SF		3
*** {Severity H}			
f. Landslides.	SF		3
*** {Severity H}			

Defect:

*** Slope Protection - Approach Channel (if applicable):**

Observation:			
a. Less than 50 SF missing, no erosion noted.	SF		
*** {Severity L}			
b. Greater than 50 SF missing, no erosion noted.	SF		
*** {Severity M}			
c. Slope protection missing, erosion noted.	SF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Channel Bottom Erosion - Approach Channel (if applicable):**			
Observation:			
a. Erosion less than 2 ft deep, not affecting control structure.	SF		
*** {Severity L}			
b. Erosion greater than 2 ft deep, not affecting control structure.	SF		
*** {Severity M}			
c. Channel bottom erosion encroaching on control structure.	SF		3
*** {Severity H}			
Defect:			
*** General Concrete Condition (Apron) - Control Structure:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Cracked concrete structure.	SF		
*** {Severity M}			
c. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			
Defect:			
*** Movement/Settlement (Apron) - Control Structure:**			
Observation:			
a. Differential movement/settlement less than 1/4".	SF		
*** {Severity L}			
b. Differential movement/settlement less than 1".	SF		
*** {Severity M}			
c. Differential movement/settlement greater than or equal to 1".	SF		3
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Spillway Cracking (Apron) - Control Structure:**			
Observation:			
a. Cracks less than 1/8" open.	LF		
*** {Severity L}			
b. Cracks between 1/8" and 1/2" open.	LF		
*** {Severity M}			
c. Single cracks greater than 1/2" open.	LF		3
*** {Severity H}			
Defect:			
*** Spillway Construction Joints - Control Structure:**			
Observation:			
a. Construction joints less than 1/8" open.	LF		
*** {Severity L}			
b. Construction joints between 1/8" and 1/2" open.	LF		
*** {Severity M}			
c. Construction joints greater than 1/2" open.	LF		3
*** {Severity H}			
Defect:			
*** General Concrete Condition (Crest) - Control Structure:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Movement/Settlement (Crest) - Control Structure:**			
Observation:			
a. Movement/settlement less than 1/4".	SF		
*** {Severity L}			
b. Movement/settlement less than 1".	SF		
*** {Severity M}			
c. Movement/settlement greater than or equal to 1".	SF		3
*** {Severity H}			
Defect:			
*** Cracking (Crest) - Control Structure:**			
Observation:			
a. Cracks less than 1/4" open.	LF		
*** {Severity L}			
b. Cracks between 1/4" and 1" open.	LF		
*** {Severity M}			
c. Single cracks greater than 1" open.	LF		3
*** {Severity H}			
Defect:			
*** General Concrete Condition (Walls) - Control Structure:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			
Defect:			
*** Wall Movement/Displacement - Control Structure:**			
Observation:			
a. Movement/settlement less than 1/4".	SF		
*** {Severity L}			
b. Movement/settlement less than 1".	SF		
*** {Severity M}			
c. Movement/settlement greater than or equal to 1".	SF		3
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Wall Cracking - Control Structure:**			
Observation:			
a. Cracks less than 1/4" open.	LF		
*** {Severity L}			
b. Cracks between 1/4" and 1" open.	LF		
*** {Severity M}			
c. Single cracks greater than 1" open.	LF		3
*** {Severity H}			
Defect:			
*** Wall Construction Joints - Control Structure:**			
Observation:			
a. Construction joints less than 1/4" open.	LF		
*** {Severity L}			
b. Construction joints between 1/4" and 1" open.	LF		
*** {Severity M}			
c. Construction joints greater than 1" open.	LF		3
*** {Severity H}			
Defect:			
*** General Condition of Gate:**			
Observation:			
a. Protective gate coating less than 25% missing, little or no deterioration	SF		
*** {Severity L}			
b. Protective coating 25% to 50% missing, none to slight surface deterioration	SF		
*** {Severity M}			
c. Protective coating greater than 50% missing, rust or deteriorated steel.	SF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Leakage (with Gate in Closed Position) - Gate:**			
Observation:			
a. Leakage less than 1 gpm.	EA		
*** {Severity L}			
b. Leakage between 1 gpm and 5 gpm.	EA		
*** {Severity M}			
c. Leakage greater than 5 gpm.	EA		
*** {Severity H}			
Defect:			
*** Gate Operation:**			
Observation:			
a. Gate operates with difficulty, partially opens.	EA		4
*** {Severity L}			
c. Gate does not open or close fully.	EA		4
*** {Severity H}			
Defect:			
*** Emergency Operating Equipment - Gate:**			
Observation:			
a. Equipment available, but in poorly maintained condition.	EA		
*** {Severity L}			
b. Equipment not available.	EA		
*** {Severity H}			
Defect:			
*** Vegetation/Debris Accumulation - Chute:**			
Observation:			
a. Channel less than 25% blocked by debris.	SF		
*** {Severity L}			
b. Channel 25% to 75% blocked by debris.	SF		
*** {Severity M}			
c. Channel greater than 75% blocked by debris.	SF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** General Concrete Condition (Wall) - Chute:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			
Defect:			
*** Movement/Settlement (Wall) - Chute:**			
Observation:			
a. Differential movement/settlement less than 1/4".	SF		
*** {Severity L}			
b. Differential movement/settlement less than 1".	SF		
*** {Severity M}			
c. Differential movement/settlement greater than or equal to 1".	SF		14
*** {Severity H}			
Defect:			
*** Construction Joints (Wall) - Chute:**			
Observation:			
a. Construction joint less than 1/4" open.	LF		
*** {Severity L}			
b. Construction joint between 1/4"and 1" open.	LF		
*** {Severity M}			
c. Construction joint greater than 1" open.	LF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Cracking (Wall) - Chute:**			
Observation:			
a. Cracks less than 1/4" open.	LF		
*** {Severity L}			
b. Cracks between 1/4"and 1" open.	LF		
*** {Severity M}			
c. Single Cracks greater than 1" open.	LF		
*** {Severity H}			
Defect:			
*** General Concrete Condition (Floor) - Chute:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			
Defect:			
*** Construction Joints (Floor) - Chute:**			
Observation:			
a. Joint separation less than 1/4" open.	LF		
*** {Severity L}			
b. Joint separation between 1/4" and 1" open.	LF		
*** {Severity M}			
c. Joint separation greater than 1" open.	LF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Movement/Settlement (Floor) - Chute:**			
Observation:			
a. Differential movement/settlement less than 1/4".	SF		
*** {Severity L}			
b. Differential movement/settlement less than 1".	SF		
*** {Severity M}			
c. Differential movement/settlement greater than 1".	SF		14
*** {Severity H}			
Defect:			
*** Cracking (Floor) - Chute:**			
Observation:			
a. Cracks less than 1/4" open.	LF		
*** {Severity L}			
b. Cracks between 1/4"and 1" open.	LF		
*** {Severity M}			
c. Single cracks greater than 1" open.	LF		
*** {Severity H}			
Defect:			
*** Seepage - Chute:**			
Observation:			
a. Observed wall dampness.	SF		
*** {Severity L}			
b. Seepage less than 1 gpm.	SF		
*** {Severity M}			
c. Seepage greater than 1 gpm.	SF		3
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Undermining - Chute:**			
Observation:			
a. Voids less than 2" thick *** {Severity L}	SF		
b. Voids 2" to 6" thick *** {Severity M}	SF		3
c. Undercutting of edge of slab, or voids greater than 6" thick *** {Severity H}	SF		3
d. Any void exhibiting piping or erosion of material from under the slab *** {Severity H}	SF		3
Defect:			
*** Vegetation/Debris Accumulation - Stilling Basin:**			
Observation:			
a. Channel less than 25% blocked by debris. *** {Severity L}	SF		
b. Channel 25% to 75% blocked by debris. *** {Severity M}	SF		
c. Channel greater than 75% blocked by debris. *** {Severity H}	SF		
Defect:			
*** General Concrete Condition (Wall) - Stilling Basin:**			
Observation:			
a. Spalling, chipped concrete. *** {Severity L}	SF		
b. Deteriorated concrete with exposed steel reinforcing. *** {Severity H}	SF		

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Movement/Settlement (Wall) - Stilling Basin:**			
Observation:			
a. Differential movement/settlement less than 1/4".	SF		
*** {Severity L}			
b. Differential movement/settlement less than 1".	SF		
*** {Severity M}			
c. Differential movement/settlement greater than 1".	SF		15
*** {Severity H}			
Defect:			
*** Construction Joints (Wall) - Stilling Basin:**			
Observation:			
a. Joint separation less than 1/4" open.	LF		
*** {Severity L}			
b. Joint separation between 1/4"and 1" open.	LF		
*** {Severity M}			
c. Joint separation greater than 1" open.	LF		
*** {Severity H}			
Defect:			
*** General Concrete Condition (Floor) - Stilling Basin:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Cracking (Floor) - Stilling Basin:**			
Observation:			
a. Cracks less than 1/4" open.	LF		
*** {Severity L}			
b. Cracks between 1/4"and 1" open.	LF		
*** {Severity M}			
c. Single cracks greater than 1" open.	LF		
*** {Severity H}			
Defect:			
*** Movement/Settlement (Floor) - Stilling Basin:**			
Observation:			
a. Differential movement/settlement less than 1/4".	SF		
*** {Severity L}			
b. Differential movement/settlement less than 1".	SF		
*** {Severity M}			
c. Differential movement/settlement greater than or equal to 1".	SF		15
*** {Severity H}			
Defect:			
*** Construction Joints (Floor) - Stilling Basin:**			
Observation:			
a. Joint separation less than 1/4" open.	LF		
*** {Severity L}			
b. Joint separation between 1/4" and 1" open.	LF		
*** {Severity M}			
c. Joint separation greater than 1" open.	LF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Undermining of Floor Slab - Stilling Basin:**			
Observation:			
a. Voids less than 2" thick	SF		
*** {Severity L}			
b. Voids 2" to 6" thick	SF		3
*** {Severity M}			
c. Undercutting of edge of slab, or voids greater than 6" thick	SF		3
*** {Severity H}			
d. Any void exhibiting piping or erosion of material from under the slab.	SF		3
*** {Severity H}			
Defect:			
*** Vegetation/Debris Accumulation - Outlet Channel:**			
Observation:			
a. Channel less than 25% blocked by debris.	SF		
*** {Severity L}			
b. Channel 25% to 75% blocked by debris.	SF		
*** {Severity M}			
c. Channel greater than 75% blocked by debris.	SF		
*** {Severity H}			
Defect:			
*** Slope Protection - Outlet Channel (if applicable):**			
Observation:			
a. Less than 50 SF missing, no erosion noted.	SF		
*** {Severity L}			
b. Greater than 50 SF missing, no erosion noted.	SF		
*** {Severity M}			
c. Slope protection missing, erosion noted.	SF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.03 SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Channel Slope Stability - Outlet Channel:**			
Observation:			
a. Soil creep.	SF		
*** {Severity L}			
b. Surface sloughing.	SF		
*** {Severity M}			
c. Rock falls.	SF		
*** {Severity M}			
d. Surface cracking.	SF		
*** {Severity M}			
e. Surface rupture.	SF		3
*** {Severity H}			
f. Landslides.	SF		3
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ 15.02.04 EMERGENCY SPILLWAY

The emergency spillway functions during periods of flooding and extremely high reservoir levels to prevent overtopping of the dam. Typically, the emergency spillway is a channel excavated in earth or rock which is located a safe distance away from the dam and eventually enters the downstream channel some distance downstream of the dam. Channels excavated in earth or easily erodible rock frequently have concrete control sections and chutes. On dams with combined principal and emergency spillways, concrete structures are common. The exit channel of an emergency spillway should be located a sufficient distance from the dam to preclude damage to the dam or appurtenant works should the spillway be used. The location and dimensions of the emergency spillway can be found in the design or construction drawings.

Inspection of an emergency spillway requires observation of defects at the approach channel, the control structure, and the outlet channel. Brief descriptions of these components follow.

The approach channel to the emergency spillway is that part of the excavated channel upstream of the control structure. During periods of normal or low reservoir level, this approach channel may be readily observable. In contrast, this same channel will appear to be a branch of the existing reservoir during periods of high reservoir levels.

Potential defects which can be observed in the emergency spillway approach channel include extensive vegetation growth or debris accumulation which obstructs flow through the channel; unstable channel side slopes or large scale stability problems occurring in slopes above the immediate channel; lack or displacement of slope protection measures; and erosion of the channel bottom which threatens to undermine the control structure.

The control structure typically consists of one of the following: 1) a concrete sill and chute placed across the width of the emergency spillway channel; 2) soil or rock excavated to form a high point along the emergency spillway channel; or 3) a concrete structure as part of a combined principal/emergency spillway. Details concerning the control structure can be obtained from design or construction drawings or can be observed and measured in the field.

Potential defects of the control structure which can be observed include deterioration of the concrete; settlement of the control sill; erosion and undermining of the control sill; or defects associated with the concrete spillway apron and crest as set forth in the Standard for Spillways.

Flow from the emergency spillway channel generally exits in a separate outlet channel which converges with the main downstream channel at some distance downstream from the dam site. For concrete dams, discharge from the emergency spillway may be directly into the downstream channel. Actual outlet channel conditions will be readily observable in the field.

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ 15.02.04 EMERGENCY SPILLWAY (Continued)

If applicable, potential defects which can be observed in an outlet channel include heavy vegetation growth or debris accumulation which obstructs flow through the outlet channel; missing or displaced slope protection measures or rapid progression of erosion upstream towards the control structure; or channel slope instability which could lead to impoundment or obstruction of flow through the outlet channel.

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Vegetation/Debris Accumulation - Approach Channel (if applicable):**			
Observation:			
a. Channel less than 25% blocked by debris. *** {Severity L}	SF		
b. Channel 25% to 75% blocked by debris. *** {Severity M}	SF		
c. Channel greater than 75% blocked by debris. *** {Severity H}	SF		
Defect:			
*** Channel Slope Stability - Approach Channel (if applicable):**			
Observation:			
a. Soil creep. *** {Severity L}	SF		
b. Surface sloughing. *** {Severity M}	SF		
c. Rock falls. *** {Severity M}	SF		
d. Surface cracking. *** {Severity M}	SF		
e. Surface rupture. *** {Severity H}	SF		5
f. Landslides. *** {Severity H}	SF		5

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.04 EMERGENCY SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Slope Movement Above Channel - Approach Channel (if applicable):**			
Observation:			
a. Soil creep.	SF		
*** {Severity L}			
b. Surface sloughing.	SF		
*** {Severity M}			
c. Rock falls.	SF		
*** {Severity M}			
d. Surface cracking.	SF		
*** {Severity M}			
e. Surface rupture.	SF		5
*** {Severity H}			
f. Landslides.	SF		5
*** {Severity H}			
Defect:			
*** Slope Protection - Approach Channel (if applicable):**			
Observation:			
a. Less than 50 SF missing, no erosion noted.	SF		
*** {Severity L}			
b. Greater than 50 SF missing, no erosion noted.	SF		
*** {Severity M}			
c. Slope protection missing, erosion noted.	SF		
*** {Severity H}			
Defect:			
*** Sedimentation - Approach Channel (if applicable):**			
Observation:			
a. Sediment accumulation below control structure level.	SF		
*** {Severity M}			
b. Sediment accumulation higher than control structure level.	SF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ 15.02.04 EMERGENCY SPILLWAY (Continued)

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** General Concrete Condition (Crest) - Control Structure:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Cracked concrete structure.	SF		
*** {Severity M}			
c. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			
d. Eroded soil or rock control structure	SF		5
*** {Severity H}			
Defect:			
*** Movement/Settlement of Crest - Control Structure:**			
Observation:			
a. Movement/settlement less than 1/4".	SF		
*** {Severity L}			
b. Movement/settlement less than 1".	SF		
*** {Severity M}			
c. Movement/settlement greater than or equal to 1".	SF		
*** {Severity H}			
Defect:			
*** Undermining of Control Structure:**			
Observation:			
a. Voids less than 2" thick	SF		
*** {Severity L}			
b. Voids 2" to 6" thick	SF		5
{Severity M}			
c. Undercutting of edge of slab, or voids greater than 6" thick	SF		5
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.04 EMERGENCY SPILLWAY (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Vegetation/Debris Accumulation - Outlet Channel:**			
Observation:			
a. Channel less than 25% blocked by debris. *** {Severity L}	SF		
b. Channel 25% to 75% blocked by debris. *** {Severity M}	SF		
c. Channel greater than 75% blocked by debris. *** {Severity H}	SF		
Defect:			
*** Channel Slope Stability - Outlet Channel:**			
Observation:			
a. Soil creep. *** {Severity L}	SF		
b. Surface sloughing. *** {Severity M}	SF		
c. Rock falls. *** {Severity M}	SF		
d. Surface cracking. *** {Severity M}	SF		
e. Surface rupture. *** {Severity H}	SF		5
f. Landslides. *** {Severity H}	SF		5
Defect:			
*** Slope Protection - Outlet Channel (if applicable):**			
Observation:			
a. less than 50 SF missing, no erosion noted. *** {Severity L}	SF		
b. greater than 50 SF missing, no erosion noted. *** {Severity M}	SF		
c. Slope protection missing, erosion noted. *** {Severity H}	SF		

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ 15.02.05 INTAKE/OUTLET WORKS

The intake/outlet works, or drawdown facility, provide a means for lowering or draining the reservoir. Dams have intake/outlet works in order to control the reservoir pool level, and to lower the reservoir level for repairs to the concrete dam or spillway or in cases when failure of the dam may be imminent.

In general, the intake/outlet facility consists of a pipe extending through the concrete dam with a valve which may be operated as needed. The drawdown valve should generally be located on the upstream side of the dam to keep water pressure in the pipe at zero.

Frequently, the drawdown facility is incorporated into the principal spillway in the form of a gate valve in the riser.

Inspection of an intake/outlet works system requires observation for defects at an intake structure, control system, outlet conduit, stilling basin, and outlet channel. Brief descriptions of these structures follow.

The intake structure is a conduit to permit water to transport from the reservoir through the dam. Design of an intake structure can range from an open pipe extending through the upstream face of the dam from the reservoir to a grate covered vertical drop intake shaft to an intake and gatehouse structure.

Potential defects which may be observed at the intake structure include missing trash racks or trash racks covered with debris; deterioration of the concrete or steel intake bulkhead and structure; displacement, settlement or separation of joints in the intake conduit; or leakage into the intake conduit or tower structure.

The control structure commonly consists of a gate or valve which can be moved across the intake/outlet conduit to control flow from the impoundment. The controls to the gate or valve may be located on the crest of the dam, housed in a gate house facility or in galleries within the dam. Details concerning the control gate or valve can be obtained from the design or construction drawings, or the operations manual, or the type and dimensions can be readily determined in the field.

Potential defects which can be observed concerning the control structure include deterioration of concrete and/or metal and leakage in the gate housing structure; deterioration and wearing of the protective coating on the gate; leakage around the gate when the gate is closed; unsatisfactory operation of the gate machinery during the time of inspection; or missing or broken lock to secure the gate.

The outlet conduit transports water from the inlet pipe and/or drop shaft through the downstream slope of the dam to the discharge pool. The outlet conduit can be a formed concrete structure or sections of steel or concrete pipe. Details concerning the outlet conduit can be obtained from the design or construction drawings, dam operations manual, or by observing the type and dimensions of the structure in the field.

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ 15.02.05 INTAKE/OUTLET WORKS (Continued)

Potential defects which may be observed in the outlet conduit include debris accumulation in the conduit; severe cracking or spalling of a concrete outlet pipe or deterioration of a steel outlet pipe; leakage (infiltration or exfiltration) in the pipe; vertical or horizontal displacement of the conduit; and lack of erosion protection at the conduit exit.

Depending on the design of the intake/outlet works, the stilling basin can be a separate structure or can be a pool within the downstream channel. The floor of the stilling basin or pool may or may not be visible, depending on tailwater level at the time of inspection. Details and dimensions of the stilling basin can be obtained from the construction drawings or can be determined in the field.

Potential defects which can be observed at the stilling basin include debris accumulation which limits the effectiveness of the outlet works; movement, settlement, or cracking of the stilling basin walls or construction joints; loss of soil behind the stilling basin walls; movement, cracking or displacement of the stilling basin floor; or erosion or undermining beneath the floor slab.

The intake/outlet works exit into the main downstream channel or into a separate outlet channel which converges with the main channel at some distance downstream of the dam. Details concerning a separate outlet channel can be obtained from the design or construction drawings.

Potential defects which can be observed in the outlet channel include missing or displaced slope protection measures; instability of the channel side slopes; or heavy vegetation growth or debris accumulation which obstructs flow through the outlet channel.

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.05 INTAKE/OUTLET WORKS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Trash Racks - Intake Structure:**			
Observation:			
a. Trash racks less than 25% covered by debris.	EA		
*** {Severity L}			
b. Trash racks 25% to 75% covered by debris.	EA		
*** {Severity M}			
c. Missing trash rack or greater than 75% covered by debris.	EA		
*** {Severity H}			
Defect:			
*** General Concrete Condition - Intake Structure:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Cracked concrete structure.	SF		
*** {Severity M}			
c. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			
Defect:			
*** Inlet Channel or Conduit (if accessible):**			
Observation:			
a. Pipe displacement, no leakage.	LF		
*** {Severity L}			
b. Pipe displacement, cumulative leakage less than 5 gpm.	LF		6
*** {Severity M}			
c. Pipe displacement, cumulative leakage greater than 5 gpm.	LF		6
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.05 INTAKE/OUTLET WORKS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** General Concrete Condition - Gate Housing Structure (if accessible):**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Cracked concrete structure.	SF		
*** {Severity M}			
c. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			
Defect:			
*** Leakage into Gate Housing Structure (if accessible):**			
Observation:			
a. Observed wall dampness.	SF		
*** {Severity L}			
b. Seepage less than 1 gpm.	EA		
*** {Severity M}			
c. Seepage greater than 1 gpm.	EA		6
*** {Severity H}			
Defect:			
*** General Condition of Gate - Control Structure (if accessible):**			
Observation:			
a. Protective gate coating less than 25% missing, little or no deterioration.	EA		
*** {Severity L}			
b. Protective coating 25% to 50% missing, little or no surface deterioration.	EA		
*** {Severity M}			
c. Protective coating greater than 50% missing, rust or deteriorated steel.	EA		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.05 INTAKE/OUTLET WORKS (Continued)**

	UOM	LEVEL II KEY	LEVEL III KEY
Defect:			
*** Leakage Around Gate (in Closed Position)**			
- Control Structure:			
Observation:			
a. Leakage less than 1 gpm.	EA		
*** {Severity L}			
b. Leakage between 1 gpm and 5 gpm.	EA		
*** {Severity M}			
c. Leakage greater than 5 gpm.	EA		
*** {Severity H}			
Defect:			
*** Gate Operation - Control Works:**			
Observation:			
a. Gate operates with little difficulty, partially opens.	EA		7
*** {Severity L}			
b. Gate does not open or fully close.	EA		7
*** {Severity H}			
Defect:			
*** Gate Security - Control Structure:**			
Observation:			
a. Lock rusted or difficult to open on control system.	EA		
*** {Severity L}			
b. No security measure observed on control system.	EA		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.05 INTAKE/OUTLET WORKS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Debris Accumulation - Outlet Conduit:**			
Observation:			
a. Outlet pipe less than 25% blocked by debris. *** {Severity L}	SF		
b. Outlet pipe 25% to 75% blocked by debris. *** {Severity M}	SF		
c. Outlet pipe greater than 75% blocked by debris. *** {Severity H}	SF		
Defect:			
*** General Concrete Condition - Outlet Pipe (if accessible):**			
Observation:			
a. Spalling, chipped concrete. *** {Severity L}	SF		
b. Cracked concrete structure. *** {Severity M}	SF		
c. Deteriorated concrete with exposed steel reinforcing. *** {Severity H}	SF		
Defect:			
*** Metalwork - Outlet Pipe (if accessible):**			
Observation:			
a. Surface rusting, less than 25% of pipe. *** {Severity L}	LF		
b. Rusting or pitted surface, less than 50% of pipe. *** {Severity M}	LF		
c. Rusting or pitted surface greater than 50% of pipe, or voids or open seams. *** {Severity H}	LF		

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.05 INTAKE/OUTLET WORKS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Vertical/Horizontal Displacement - Outlet Pipe (if accessible):**			
Observation:			
a. Pipe displacement, no leakage.	LF		
*** {Severity L}			
b. Pipe displacement, cumulative leakage less than 5 gpm.	LF		6
*** {Severity M}			
c. Pipe displacement, cumulative leakage greater than 5 gpm.	LF		6
*** {Severity H}			
Defect:			
*** Erosion Protection at Pipe Outlet:**			
Observation:			
a. Erosion protection missing, no erosion noted.	SF		
*** {Severity M}			
b. Erosion protection missing, erosion noted.	SF		
*** {Severity H}			
Defect:			
*** Debris Accumulation - Stilling Basin:**			
Observation:			
a. Stilling basin less than 25% blocked by debris.	SF		
*** {Severity L}			
b. Stilling basin 25% to 75% blocked by debris.	SF		
*** {Severity M}			
c. Stilling basin greater than 75% blocked by debris.	SF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.05 INTAKE/OUTLET WORKS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** General Concrete Condition (Wall) - Stilling Basin:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity H}			
Defect:			
*** Movement/Settlement (Wall) - Stilling Basin:**			
Observation:			
a. Differential movement/settlement less than 1/4".	SF		
*** {Severity L}			
b. Differential movement/settlement less than 1".	SF		
*** {Severity M}			
c. Differential movement/settlement greater than 1".	SF		14
*** {Severity H}			
Defect:			
*** Construction Joints (Wall) - Stilling Basin:**			
Observation:			
a. Joint separation less than 1/4" open.	LF		
*** {Severity L}			
b. Joint separation less than 1" open.	LF		
*** {Severity M}			
c. Joint separation greater than 1" open.	LF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.05 INTAKE/OUTLET WORKS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Cracking (Walls) - Stilling Basin:**			
Observation:			
a. Cracks less than 1/4" open.	LF		
*** {Severity L}			
b. Cracks between 1/4" and 1" open.	LF		
*** {Severity M}			
c. Single cracks greater than 1" open.	LF		
*** {Severity H}			
Defect:			
*** General Concrete Condition (Floor) - Stilling Basin:**			
Observation:			
a. Spalling, chipped concrete.	SF		
*** {Severity L}			
b. Deteriorated concrete with exposed steel reinforcing.	SF		
*** {Severity M}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.05 INTAKE/OUTLET WORKS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Movement/Settlement (Floor) - Stilling Basin:**			
Observation:			
a. Differential movement/settlement less than 1/2".	SF		
*** {Severity L}			
b. Differential movement/settlement between 1/2" and 2".	SF		
*** {Severity M}			
c. Differential movement/settlement greater than 2".	SF		15
*** {Severity H}			
Defect:			
*** Construction Joints (Floor) - Stilling Basin:**			
Observation:			
a. Joint separation less than 1/2" open.	LF		
*** {Severity L}			
b. Joint separation between 1/2" and 1" open.	LF		
*** {Severity M}			
c. Joint separation greater than 1" open.	LF		
*** {Severity H}			
Defect:			
*** Cracking (Floor) - Stilling Basin:**			
Observation:			
a. Cracks less than 1/2" open.	LF		
*** {Severity L}			
b. Cracks between 1/2" and 1" open.	LF		
*** {Severity M}			
c. Single cracks greater than 1" open.	LF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.05 INTAKE/OUTLET WORKS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Erosion Under Slab - Stilling Basin:**			
Observation:			
a. Voids less than 2" thick.	SF		
*** {Severity L}			
b. Voids 2" to 6" thick.			6
*** {Severity M}			
c. Undercutting of edge of slab, or voids greater than 6" thick.	SF		6
*** {Severity H}			
d. Any void exhibiting piping or erosion of material from under the slab.	SF		6
*** {Severity H}			

Defect:

*** Vegetation/Debris Accumulation - Outlet Channel:**

Observation:			
a. Channel less than 25% blocked by debris.	SF		
*** {Severity L}			
b. Channel 25% to 75% blocked by debris.	SF		
*** {Severity M}			
c. Channel greater than 75% blocked by debris.	SF		
*** {Severity H}			

Defect:

*** Slope Protection - Outlet Channel:**

Observation:			
a. Less than 50 SF missing, no erosion noted.	SF		
*** {Severity L}			
b. Greater than 50 SF missing, no erosion noted.	SF		
*** {Severity M}			
c. Slope protection missing, erosion noted.	SF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.05 INTAKE/OUTLET WORKS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Channel Side Slope Stability - Outlet Channel:**			
Observation:			
a. Soil creep.	SF		
*** {Severity L}			
b. Surface sloughing.	SF		
*** {Severity M}			
c. Rock falls.	SF		
*** {Severity M}			
d. Surface cracking.	SF		
*** {Severity M}			
e. Surface rupture.	SF		6
*** {Severity H}			
f. Landslides.	SF		6
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ 15.02.06 RESERVOIR

The reservoir is the impoundment of water formed by the blockage of an existing river or stream by the a dam.

Conditions which require observation during inspection of the reservoir include the reservoir level, and landslides or beach erosion around the rim of the reservoir. Brief descriptions of conditions to look for while observing the reservoir follow.

Reservoir levels can be determined by observing the reservoir level gauge set up adjacent to the embankment or spillway, or located on a structure within the reservoir.

Potential defects associated with observed reservoir levels include a missing or malfunctioning reservoir level gauge, the reservoir level being either too high or too low, or observance of whirlpools or vortexes in the reservoir near the dam or reservoir rim which may indicate loss of water from the reservoir to some unknown location.

Landslides are a potential problem for reservoirs. Instability of the slopes above the reservoir have resulted in instances where landslides have fallen into the reservoir, causing a repercussive wave which overtops the dam and causes significant consequences to the downstream environment. Identification of conditions leading to large scale movement is difficult and requires some degree of expertise in the observation and evaluation of landslides. The object of the inspection of the reservoir rim for the periodic maintenance inspection is to identify and locate areas where landslides have already occurred and estimate its size.

Beach erosion along the rim of the reservoir is generally the result of wind driven waves encountering the surrounding ground surface. Beach erosion can lead to instability of adjacent reservoir rim slopes or, in extreme cases, form a new outlet for the reservoir through erosion or uncovering outlets through sinkholes.

Potential defects include excessive erosion along the rim of the reservoir as well as the uncovering or development of sinkholes or depressions along the reservoir rim.

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Reservoir Level Gauge:**			
Observation:			
a. Reservoir level gauge not completely legible.	EA		
*** {Severity L}			
b. Reservoir level gauge missing or broken.	EA		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.06 RESERVOIR (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Reservoir Level Too High:**			
Observation:			
a. Reservoir level encroaches on design freeboard. *** {Severity L}	EA		
b. Reservoir level within 3 ft of top of dam. *** {Severity H}	EA		
Defect:			
*** Reservoir Level Too Low:**			
Observation:			
a. Reservoir level 3 ft or less above the lowest control elevation. *** {Severity M}	EA		
b. Reservoir is dry for unexplainable reason. *** {Severity H}	EA		8
Defect:			
*** Whirlpools (in Reservoir):**			
Observation:			
a. Whirlpool located greater than 200 ft from dam. *** {Severity L}	EA		8
b. Whirlpools less than 200 ft from dam due to intake operations. *** {Severity M}	EA		8
c. Unexplained observed whirlpools less than 200 ft from dam. *** {Severity H}	EA		8
Defect:			
*** Landslides - Reservoir Rim:**			
Observation:			
a. Old or ancient landslide scars. *** {Severity L}	EA		8
b. Observed landslide not recorded during last inspection. *** {Severity H}	EA		8

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.06 RESERVOIR (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Beach Erosion - Reservoir Rim:**			
Observation:			
a. Erosion causing instability of reservoir rim slopes.	SF		8
*** {Severity M}			
b. Erosion nearly progressed to lower reservoir control level.	SF		8
*** {Severity H}			
Defect:			
*** Sinkholes/Surface Depressions - Reservoir Rim:**			
Observation:			
a. Sinkholes located above high water level of reservoir	SF		8
*** {Severity M}			
b. Sinkholes within high water level reach of reservoir.	SF		8
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ 15.02.07 DOWNSTREAM CHANNEL

The downstream channel is the original stream bed or river channel located downstream of the dam. Different regulations have varying definitions for what qualifies as a "downstream environment zone"; however, in general, the downstream environment zone is defined as the area downstream from a dam that would be affected by inundation in the event the dam failed when filled to the maximum level attained during a Probable Maximum Flood event or to the dam crest elevation, whichever is lower.

The downstream channel should be relatively free draining. Pools of water should not be allowed to pond against the toe of the dam.

Potential defects which can be observed in the downstream channel include vegetation growth, debris accumulation, or development of animal habitat which could obstruct flow through the channel; signs of erosion progressing upstream towards the toe of the dam; seepage through the dam or abutments which flows into the channel; or signs of sand boils or water plumes in the downstream channel.

The side slopes of the downstream channel are critical in that they must exhibit some degree of stability so that material will not fall into and block flow through the downstream channel. The channel slopes are generally comprised of soil, rock, or mixture of both.

Potential defects which should be looked for in the side slopes of the downstream channel include landslides, surface sloughing, and other signs of channel slope instability; slope erosion; and seepage passing from the reservoir through the abutment areas and exiting the downstream channel side slopes.

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Vegetation/Debris Accumulation - Downstream Channel:**			
Observation:			
a. Channel less than 25% blocked by debris.	SF		
*** {Severity L}			
b. Channel 25% to 75% blocked by debris.	SF		
*** {Severity M}			
c. Channel greater than 75% blocked by debris.	SF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.07 DOWNSTREAM CHANNEL (Complete)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Animal Habitat - Downstream Channel:**			
Observation:			
a. Animal habitat blocking less than 25% of channel.	SF		
*** {Severity L}			
b. Animal habitat blocking 25% to 75% of channel.	SF		
*** {Severity M}			
c. Animal habitat blocking greater than 75% of channel or impounding water against toe of dam.	SF		
*** {Severity H}			
Defect:			
*** Channel Erosion - Downstream Channel:**			
Observation:			
a. Erosion causing slope stability problems greater than 200 ft downstream of dam.	SF		
*** {Severity L}			
b. Erosion causing slope stability problems less than 200 ft downstream of dam.	SF		9
*** {Severity M}			
c. Erosion encroaching on toe of dam.	SF		9
*** {Severity H}			
Defect:			
*** Seepage - Downstream Channel:**			
Observation:			
a. Seepage occurs greater than 100 ft downstream of dam.	SF		
*** {Severity L}			
b. Seepage occurs between 50 ft and 100 ft downstream of dam.	SF		9
*** {Severity M}			
c. Seepage occurs less than 50 ft downstream of dam.	SF		9
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.07 DOWNSTREAM CHANNEL (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Sand Boils/Water Plumes - Downstream Channel:**			
Observation:			
a. Sand boils/water plumes observed greater than 500 ft downstream of dam.	EA		
*** {Severity L}			
b. Sand boils/water plumes observed between 50 ft and 500 ft downstream of dam.	EA		9
*** {Severity M}			
c. Sand boils/water plumes observed less than 50 ft downstream of dam.	EA		9
*** {Severity H}			
Defect:			
*** Channel Slope Stability - Side Slopes:**			
Observation:			
a. Soil creep.	SF		
*** {Severity L}			
b. Surface sloughing.	SF		
*** {Severity M}			
c. Rock falls.	SF		
*** {Severity M}			
d. Surface cracking.	SF		
*** {Severity M}			
e. Surface rupture.	SF		9
*** {Severity H}			
f. Landslides.	SF		9
*** {Severity H}			
Defect:			
*** Slope Protection (if applicable) - Side Slopes:**			
Observation:			
a. Less than 100 SF missing, no erosion noted.	SF		
*** {Severity L}			
b. Greater than 100 SF missing, no erosion noted.	SF		
*** {Severity M}			
c. Slope protection missing, erosion noted.	SF		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.07 DOWNSTREAM CHANNEL (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Seepage - Side Slopes:**			
Observation:			
a. Seepage occurs greater than 100 ft downstream of dam.	SF		
*** {Severity L}			
b. Seepage occurs between 50 ft and 100 ft downstream of dam.	SF		9
*** {Severity M}			
c. Seepage occurs less than 50 ft downstream of dam.	SF		9
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ 15.02.08 POWER STRUCTURE

Due to its capacity to store and discharge water, many concrete dams include hydroelectric power plant facilities. These power structures should be inspected during a periodic maintenance inspection if the structures are related to the safe operation or structural integrity of the dam.

Inspection of a power structure requires observation of defects, where applicable, at the intake structure, penstocks, and tail race. Brief descriptions of these components follow.

The intake structure is the facility where water from the reservoir enters the power plant. Configurations for the intake structure can vary considerably, but in each case, will include some type of control intake gate structure. Details concerning the intake structure are found in the design or construction drawings.

Potential defects which should be looked for during inspection of the intake structure include accumulation of debris on the trash racks which could hinder flow into the intake structure; deteriorated condition of the gate and its protective coating; lack of posted instructions to operate the gate; or faulty performance in gate operation during time of inspection. Inspection of the electrical and mechanical aspects of the intake gate hoist should be performed in accordance with Standards for Building Electrical and Electrical Distribution.

The penstock is a pipeline or pressure shaft leading from the headrace or reservoir to the turbines housed in a power plant structure. Details concerning the penstock can be obtained from the design and construction drawings.

A Level I inspection of a penstock includes observations for deterioration, cracking or movement of the power plant walls and substructure. This inspection is to be performed only if it is determined that the power structure is related to the safe operation or structural integrity of the dam and is only performed to document existing general structural conditions which are readily observable.

Detailed inspection of the power plant structure should be performed by structural inspectors in accordance with Standards for Building Substructure, Building Superstructure, and Building Exterior. Due to varying penstock designs, the penstock may not be readily accessible for a Level I inspection. If such is the case, then a Level III inspection will be required.

Potential defects which could be observed in the penstock and power house structure include cracking, settlement, or displacement of the powerhouse and penstock walls or substructure, or leakage or observed displacement of the penstock structure.

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ 15.02.08 POWER STRUCTURE (Continued)

The tail race is a tunnel, channel or conduit that conveys the discharge from a powerplant turbine to the river.

Where accessible, a Level I inspection of the tail race should include observation for existing surface defects such as cracking, displacement or leakage. This inspection is to be performed only if it is determined that the power structure is related to the safe operation or structural integrity of the dam and is only performed to document existing general structural conditions which are readily observable.

Detailed inspection of the tail race should be performed by structural inspectors in accordance with the Level III Standards for Tunnels. Due to varying designs, the tail race may not be readily accessible for a Level I inspection. If such is the case, then an inspection will be performed during a regularly scheduled Level III inspection.

Potential defects which could be observed in the tail race include cracking, settlement, or displacement of the tail race structure or observed leakage along the tail race.

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Trash Rack - Intake Structure:**			
Observation:			
a. Trash rack less than 25% obstructed by debris.	EA		
*** {Severity L}			
b. Trash rack 25% to 75% obstructed by debris.	EA		
*** {Severity M}			
c. Missing trash rack or greater than 75% obstructed by debris.	EA		
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.08 POWER STRUCTURE (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** General Condition of Intake Gate - Intake Structure:**			
Observation:			
a. Protective gate coating less than 25% missing, little or no deterioration	SF		
*** {Severity L}			
b. Protective coating 25% to 50% missing, none to slight surface deterioration	SF		
*** {Severity M}			
c. Protective Coating greater than 50% missing, rust or deteriorated steel.	SF		
*** {Severity H}			
Defect:			
*** Gate Operation at Time of Inspection - Intake Structure:**			
Observation:			
a. Gate operates with little difficulty, partially opens.	EA		10
*** {Severity L}			
b. Gate does not open or fully closes.	EA		10
*** {Severity H}			
Defect:			
*** Penstock/Power Structure Walls:**			
Observation:			
a. Walls exhibit cracking	LF		11
*** {Severity L}			
b. Walls exhibit displacement or settlement.	SF		11
*** { Severity M}			
c. Walls exhibit leakage.	SF		11
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.08 POWER STRUCTURE (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Penstock/Power Structure:**			
Observation:			
a. Floor or exposed foundations exhibit cracking. *** {Severity L}	SF		11
b. Floor or exposed foundations exhibit displacement or settlement. *** { Severity M}	SF		11
c. Floor exhibits seepage. *** {Severity H}	SF		11
Defect:			
*** Tail Race Structure:**			
Observation:			
a. Tail race exhibits cracking. *** {Severity L}	SF		11
b. Tail race exhibits displacement or settlement. *** { Severity M}	SF		11
c. Tail race exhibits leakage. *** {Severity H}	SF		11
Defect:			
*** Tail Race Bulkhead:**			
Observation:			
a. Bulkhead exhibits cracking. *** {Severity L}	SF		11
b. Bulkhead exhibits displacement or settlement. *** { Severity M}	SF		11
c. Bulkhead exhibits leakage. *** {Severity H}	SF		11

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ 15.02.09 ACCESS ROADS

Access roads to the dam site should be kept open at all times other than to perform maintenance work on an as-needed basis. As part of the Level I inspection, the access road should be inspected if it is located along the crest of the concrete dam or where it crosses the downstream channel. Full inspection of the access road should be performed under the Standard prepared for Pavements/Improved Surfaces.

Level I inspection should be performed to ensure that the access roadway is clear for emergency vehicular traffic. Any temporary closures or blockages of the access road due to maintenance or construction work activities should be noted. Railings should also be observed to ensure that they are in place for roadways along the crest of the dam.

Potential defects which could be observed along an access road include blockage of the roadway due to fallen trees, rocks, or debris to such condition that passage of emergency vehicles may be difficult.

Any bridges along the access road should be briefly inspected during the Level I inspection to ensure that passage along the roadway is achievable. Full scale inspections of the bridge should be performed in accordance to the frequency and conditions set forth in the Standards for Bridges.

Potential defects which should be looked for during the Level I inspection include deterioration of the general condition of the bridge to such extent that the bridge will not be accessible to traffic during an emergency condition.

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Roadway Clearance - Access Road:**			
Observation:			
a. Roadway temporarily blocked due to maintenance or construction activity.	LF		
*** {Severity L}			
b. Long term blockage due to slope instability or deteriorated pavement.	LF		12
*** {Severity H}			

15.02 CONCRETE DAMS

COMPONENTS (Continued)

◆ **15.02.09 ACCESS ROADS (Continued)**

Defect:	UOM	LEVEL II KEY	LEVEL III KEY
*** Debris Accumulation/Obstruction:**			
Observation:			
a. Roadway partially blocked by debris.	LF		
*** {Severity L}			
b. Roadway greater than 75% blocked by debris.	LF		
*** {Severity M}			

Defect:

*** General Bridge Condition (if applicable):**			
Observation:			
a. Bridge accessible to traffic, partially blocked.	EA		12
*** {Severity M}			
b. Bridge inaccessible to traffic.	EA		12
*** {Severity H}			

15.02 CONCRETE DAMS

REFERENCES

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993.

2. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

3. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

4. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

5. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

6. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

7. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

8. Engineering Foundation Conference Proceedings, Inspection, Maintenance and Rehabilitation of Old Dams, American Society of Civil Engineers, 1973.

9. American Society of Civil Engineers and United States Committee on Large Dams, Joint ASCE-USCOLD Committee on Current United States Practice in the Design and Construction of Arch Dams, Embankment Dams, and Concrete Gravity Dams, 1967.

10. Engineering Foundation Conference Proceedings, The Evaluation of Dam Safety, American Society of Civil Engineers, 1976.

11. Glossary of Geology, Second Edition, American Geological Institute, 1980.

12. U.S. Department of the Interior Bureau of Reclamation, General Checklist for Examination of Concrete Dams.

13. U.S. Army Corp of Engineers, ER 1110-2-106, Recommended Guidelines for Safety Inspection of Dams, September 1979.

14. Rules and Regulations of the Missouri Dam and Reservoir Safety Council, Missouri Department of Natural Resources Division of Geology and Land Survey.

15.02 CONCRETE DAMS

REFERENCES (Continued)

15. Engineering Guidelines for the Evaluation of Hydropower Projects, Federal Energy Regulatory Commission Office of Hydropower Licensing, April, 1991.

16. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987.

15.02 CONCRETE DAMS

LEVEL II KEY	GUIDE SHEET CONTROL NUMBER
N/A	

LEVEL III KEY	GUIDE SHEET CONTROL NUMBER
1	GS-III 15.02.01-1
2	GS-III 15.02.06-2
3	GS-III 15.02.06-3
4	GS-III 15.02.03-4
5	GS-III 15.02.03-5
6	GS-III 15.02.04-6
7	GS-III 15.02.06-7
8	GS-III 15.02.06-8
9	GS-III 15.02.07-9
10	GS-III 15.02.08-10
11	GS-III 15.02.08-11
12	GS-III 15.02.09-12
13*	GS-III 15.02-13*
14	GS-III 15.02.05-14
15	GS-III 15.02.05-15

* *Indicates Guide Sheets which are not directly referenced with a Key. These inspections are "triggered" by conditions beyond the inspection process such as time, age or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 1

COMPONENT: CONCRETE DAM STRUCTURE
CONTROL NUMBER: GS-III 15.02.01-1

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of observable defects recorded in Level I or Level II defect observations of the concrete dam structure.

Whereas the purpose of the Level I or II inspection was to record the observable defects at readily accessible components of the concrete dam structure, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam and it's appurtenant works.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multi-disciplined team of engineers experienced in the design and construction of concrete dams.

The results of the Level III inspection can be used to develop maintenance or remedial measure work strategy that will correct the existing deficiency conditions of the concrete dam structure or to require continued monitoring of existing deficiency conditions at the concrete dam.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III test and inspection method. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during the Level I or II inspection.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Concrete Dams.

For inspection work performed by boat or inspection of existing galleries or foundation tunnels through the concrete dam, the inspection team shall consists of a minimum of two personnel.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 1 (Continued)

COMPONENT: CONCRETE DAM STRUCTURE
CONTROL NUMBER: GS-III 15.02.01-1

Inspection Actions

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defected component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

2. Perform inspection of the pertinent components where observed defects targeting a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed at the concrete dam structure. Indicate priorities for any required maintenance, or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimate for required maintenance or remedial repair measures, as applicable.

Level III advanced inspection methods may be required for many different Level I and Level II defect conditions observed in a concrete dam structure. Level III advanced test or inspection methods and associated observed defects for an concrete dam include, but are not limited to the following:

Non-Standard Test or Inspection Method	Applicable Observed Defects
1. dye testing	erosion or cavitation of concrete
2. piezometer installation	seepage, wet zones
3. relief wells	wet zones, clogged toe drains, seepage
4. test borings	settlement, undermining, erosion
5. concrete coring	concrete condition,

LEVEL III INSPECTION METHOD GUIDE SHEET

Non-Standard Test or Inspection Method	Applicable Observed Defects
6. laboratory tests on concrete cores (strength tests, petrographic analysis, density, impact, porosity and permeability, modulus of elasticity, abrasion, adsorption)	concrete condition
7. infrared thermography	voids, seepage
8. ground probing radar	voids
9. slope inclinometers	measurement monument, structural displacement
10. monuments for vertical and horizontal movement (pins, monuments, plates, gages, etc.)	concrete dam movement
11. crest settlement monuments	crest settlement
12. flow measurement readings	seepage, leakage
13. survey measurements	existing drawings do not match field observations
14. sonic testing (geophysical)	concrete condition
15. seepage mapping	seepage through downstream face of dam or abutments
16. underwater inspection	inspection of upstream face of dam, erosion at toe of dam

Special Safety Equipment

Special safety equipment needed for the Level III inspection of components of a concrete dam and appurtenant works are listed in the standards developed for the Standard Inspection of Concrete Dams.

Approved safety life vests must be worn by all inspection personnel when using boats for inspection purposes or when walking across high spillway crests.

Special Instructions

Review as-built and design drawings of structure.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 1 (Continued)

COMPONENT: CONCRETE DAM STRUCTURE
CONTROL NUMBER: GS-III 15.02.01-1

Special Tools and Equipment

Equipment designated in Level I inspections
Survey Level and rod
Navigable boat with approved life preservers
Standard testing equipment required to perform the non-standard test or investigation method

Recommended Inspection Frequency

Concrete Dam Structure - as needed basis

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993.

2. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

3. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

4. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

5. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

6. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

7. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

8. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 2

COMPONENT: ABUTMENTS
CONTROL NUMBER: GS-III 15.02.02-2

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of defects recorded in Level I or Level II defect observations of the abutments of a concrete dam.

Whereas the purpose of the Level I inspection was to record the observable defects at the dam abutments, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam and it's appurtenant works.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multi-disciplined team of engineers experienced in the design and construction of concrete dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing deficiency conditions or to require continued monitoring of existing deficiency conditions at the abutments.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III test and inspection method. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Equipment

Special safety equipment needed for the Level III inspection of the abutments are listed in the standards developed for the Standard Inspection of Concrete Dams.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Concrete Dams.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 2 (Continued)

COMPONENT: ABUTMENTS
CONTROL NUMBER: GS-III 15.02.02-2

Inspection Action

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

2. Perform inspection of the pertinent components where observed defects that triggered a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance,or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimate for required maintenance or remedial repair measures, as applicable.

Level III advanced inspection methods may be required for several Level I and Level II defect conditions observed at a concrete dam site. Level III advanced test or inspection methods and associated observed defects for abutments include, but are not limited to the following:

Advanced Test or Inspection Method	Applicable Observed Defects
1. backhoe excavations	soft zones, slope instability,
2. dye testing	seepage
3. piezometer installation	slope instability, seepage, wet zones
4. relief wells	wet zones, clogged toe drains, seepage

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 2 (Continued)

COMPONENT: ABUTMENTS
CONTROL NUMBER: GS-III 15.02.02-2

Advanced Test or Inspection Method	Applicable Observed Defects
5. soil borings	slope instability, erosion
6. laboratory tests on soil samples (strength tests, moisture content, consolidation tests, etc.)	slope instability
7. infrared thermography	voids, sinkholes, seepage
8. ground probing radar	voids
9. slope inclinometers	slope stability
10. slope movement monuments	slope movement, slope stability
11. erosion survey monuments	extensive or rapidly progressing erosion along abutments
12. flow measurement readings	seepage, leakage
13. geophysical surveys (sonic, downhole and crosshole arrays, seismic reflection, refraction, etc.)	slope stability

Special Instructions

Review as-built and design drawings of structure.

Special Tools & Equipment Requirements

Equipment designated in Level I inspections
Survey Level and rod
Navigable boat with approved life preservers
Industry required testing equipment needed to perform the advanced investigation method chosen

Recommended Inspection Frequency

Abutments - as needed basis

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 2 (Continued)

COMPONENT: ABUTMENTS
CONTROL NUMBER: GS-III 15.02.02-2

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993.

2. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

3. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

4. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

5. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

6. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

7. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

8. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 3

COMPONENT: SPILLWAY
CONTROL NUMBER: GS-III 15.02.03-3

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of observable defects recorded in Level I or Level II defect observations of the spillway.

Whereas the purpose of the Level I and II inspections was to record the observable defects at readily accessible components of the spillway, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam and the spillway.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multi-disciplined team of engineers experienced in the design and construction of concrete dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing defect condition or to require continued monitoring of existing deficiency conditions at the spillway.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III inspection. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Concrete Dams.

For inspection work performed by boat, the inspection team shall consist of a minimum of two personnel.

Inspection Action

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 3 (Continued)

COMPONENT: SPILLWAY
CONTROL NUMBER: GS-III 15.02.03-3

Inspection Action (Continued)

2. Perform inspection of the pertinent component where observed defects that triggered a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimates for required maintenance or remedial repair measures, if applicable.

Level III advanced test and inspection methods may be required for many different Level I and II defect conditions observed in a spillway system. Level III advanced test or inspection methods and associated observed defects include, but are not limited to the following:

Advanced Test or Inspection Method	Applicable Observed Defects
backhoe excavations	slope instability, sedimentation accumulation
dye testing	seepage, sinkholes
piezometer installation	slope instability, seepage, wet zones
relief wells	wet zones, seepage
test borings	slope instability, settlement, undermining, erosion cracking or unusual movement at toe of dam.
laboratory tests on soil samples (strength tests, moisture content, consolidation tests, etc.)	slope instability

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 3 (Continued)

COMPONENT: SPILLWAY
CONTROL NUMBER: GS-III 15.02.03-3

Advanced Test or Inspection Method	Applicable Observed Defects
concrete coring	concrete deterioration, cracking or unusual movement at toe of dam
laboratory tests on concrete cores (strength tests, abrasion, absorption, sulfate soundness, unit weight)	concrete deterioration, leakage
infrared thermography	voids, seepage,
ground probing radar	voids
slope inclinometers	slope stability, measurement monument, structural displacement
slope movement monuments	slope movement, slope stability
crest settlement monuments	crest settlement
erosion survey monuments	extensive or rapidly progressing erosion in downstream channels,
flow measurement readings	seepage, leakage
survey measurements	existing drawings do not match field observations, baseline for erosion monitoring
geophysical surveys (sonic, downhole and crosshole arrays, seismic reflection, refraction, etc.)	slope stability, undermining
underwater inspection	evaluating spillway undermining.

Special Instructions

Review as-built and design drawings of structure.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 3 (Continued)

COMPONENT: SPILLWAY
CONTROL NUMBER: GS-III 15.02.03-3

Special Tools and Equipment

Equipment designated in Level I inspections
Survey Level and rod
Standard testing equipment required to perform the non-standard test or investigation method

Special Safety Equipment

Special safety equipment needed for the Level III inspection of a spillway are listed in the standards developed for the Standard Inspection of Concrete Dams.

Approved safety life vests must be worn by all inspection personnel when using boats for inspection purposes or when walking across high spillway crests.

Recommended Inspection Frequency

Spillway - as needed basis

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 3 (Continued)

COMPONENT: SPILLWAY
CONTROL NUMBER: GS-III 15.02.03-3

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993.

2. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

3. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

4. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

5. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

6. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

7. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

8. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 4**

COMPONENT: SPILLWAY
CONTROL NUMBER: GS-III 15.02.03-4

Application

This guide has been prepared to identify the purpose of a Level III inspection of the spillway gate operations.

The results of the Level III inspection can be used to trigger a Level III inspection or necessary repair or remedial measure activities.

Special Safety Equipment

No special safety requirements are needed for the Level III inspection of spillway gate operations beyond the requirements listed in the standards developed for the Standard Inspection of Concrete Dams.

Special Safety Requirements

Operating the spillway gate(s) will temporarily affect the downstream environment of the dam. Inspection of gate operations must be performed only after prior notification of the Facility Manager or person responsible for the dam structure, and the inspection personnel must check in with the above personnel upon completion of the inspection process.

Inspection of gate operations requires a minimum of two personnel at the gate control system site. The second person should be one who is completely familiar with the operation of the gate structure and actually operates the gate during the inspection.

Inspection Items

1. Two personnel present at the gate control system site.

2. Review operating instructions for the gate.

3. Partially open the gate (mechanical or electrical operated) by appropriate controlling of the gate control system. Allow any debris caught by the gate to be washed over the spillway control structure.

4. Open the gate to the "full open" position unless it is necessary to limit gate travel because of low reservoir level. Allow the water to clear any debris from the spillway gate or stilling basin. Observe water exiting the stilling basin or outlet channel. The gate should be left fully open for not longer than 60 seconds.

5. Close the gate structure completely. Observe closed gate for leakage over the control crest. Notify the Facility Manager immediately if unable to close the gate.

** *This Guide Sheet is triggered by conditions beyond the inspection process such as time, age, or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 4 (Continued)**

COMPONENT: SPILLWAY
CONTROL NUMBER: GS-III 15.02.03-4

Special Tools and Equipment Requirements

Equipment designated for use in gate operations

Required Inspection Frequency

Gate Operations, Spillway - 1 year intervals

References

1. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982.

2. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

3. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

4. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

5. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

6. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

7. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

8. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987.

** *This Guide Sheet is triggered by conditions beyond the inspection process such as time, age, or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 5

COMPONENT: EMERGENCY SPILLWAY
CONTROL NUMBER: GS-III 15.02.04-5

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of observable defects recorded in Level I or Level II defect observations of the emergency spillway.

Whereas the purpose of the Level I and II inspections was to record the observable defects at readily accessible components of the emergency spillway, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam and the emergency spillway.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multi-disciplined team of engineers experienced in the design and construction of concrete dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing defect condition or to require continued monitoring of existing deficiency conditions at the emergency spillway.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III inspection. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Concrete Dams.

Inspection Action

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 5 (Continued)

COMPONENT: EMERGENCY SPILLWAY
CONTROL NUMBER: GS-III 15.02.04-5

Inspection Action (Continued)

2. Perform inspection of the pertinent component where observed defects that triggered a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimates for required maintenance or remedial repair measures, if applicable.

Level III advanced test and inspection methods may be required for many different Level I and II defect conditions observed in an emergency spillway system. Level III advanced test or inspection methods and associated observed defects include, but are not limited to the following:

Advanced Test or Inspection Method	Applicable Observed Defects
backhoe excavations	soft zones, slope instability, sedimentation accumulation
dye testing	seepage, sinkholes
piezometer installation	slope instability, seepage, wet zones
relief wells	wet zones, seepage
test borings	slope instability, settlement, undermining, erosion
laboratory tests on soil samples (strength tests, moisture content, consolidation tests, etc.)	slope instability

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 5 (Continued)

COMPONENT: EMERGENCY SPILLWAY
CONTROL NUMBER: GS-III 15.02.04-5

Advanced Test or Inspection Method	Applicable Observed Defects
infrared thermography	voids, seepage,
ground probing radar	voids
slope inclinometers	slope stability, measurement monument, structural displacement
slope movement monuments	slope movement, slope stability
crest settlement monuments	crest settlement
erosion survey monuments	extensive or rapidly progressing erosion in downstream channels,
flow measurement readings	seepage, leakage
survey measurements	existing drawings do not match field observations, baseline for erosion monitoring
geophysical surveys (sonic, downhole and crosshole arrays, seismic reflection, refraction, etc.)	slope stability, undermining
underwater inspection	evaluating spillway undermining.

Special Instructions

Review as-built and design drawings of structure.

Special Tools and Equipment

Equipment designated in Level I inspections
Survey Level and rod
Standard testing equipment required to perform the non-standard test or investigation method

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 5 (Continued)

COMPONENT: EMERGENCY SPILLWAY
CONTROL NUMBER: GS-III 15.02.04-5

Special Safety Equipment

Special safety equipment needed for the Level III inspection of a spillway are listed in the standards developed for the Standard Inspection of Concrete Dams.

Approved safety life vests must be worn by all inspection personnel when using boats for inspection purposes or when walking across high spillway crests.

Recommended Inspection Frequency

Emergency Spillway - as needed basis

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993

2. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977

3. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974

4. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983

5. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987

6. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987

7. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987

8. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 6

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.02.05-6

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of observable defects recorded in Level I or Level II defect observations of the intake/outlet works.

Whereas the purpose of the Level I and II inspections was to record the observable defects at readily accessible components of the intake/outlet works, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam and the intake/outlet works.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multi-disciplined team of engineers experienced in the design and construction of concrete dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing defect condition or to require continued monitoring of existing deficiency conditions at the intake/outlet works.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III inspection. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Concrete Dams.

For entry into any intake/outlet works structure, operation of any gate facility, or inspection work item performed by boat, the inspection team shall consists of a minimum of two personnel. Any person entering the intake/outlet works structure must have a safety rope and protective harness, and other safety equipment or measures as required by OSHA and all other agencies having jurisdiction.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 6 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.02.05-6

Inspection Actions

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

2. Perform inspection of the pertinent component where observed defects that triggered a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimates for required maintenance or remedial repair measures, if applicable.

Level III advanced test and inspection methods may be required for many different Level I and II defect conditions observed in an intake/outlet work system. Level III advanced test or inspection methods and associated observed defects include, but are not limited to the following:

Advanced Test or Inspection Method	Applicable Observed Defects
1. dye testing	seepage
2. test borings	undermining, erosion

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 6 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.02.05-6

Advanced Test or Inspection Method	Applicable Observed Defects
3. infrared thermography	voids, seepage, poor drainage
4. ground probing radar	voids
5. flow measurement readings	seepage, leakage
6. geophysical surveys (sonic, downhole and crosshole arrays, seismic reflection, refraction, etc.)	undermining
7. underwater inspection	closing intake structure, inspection of intake structure, evaluating undermining conditions

Special Tools and Equipment

1. Equipment designated in Level I inspections
2. Survey Level and rod
3. Navigable boat with approved life preservers
4. Standard testing equipment required to perform the non-standard test or investigation method

Special Instructions

Review as-built and design drawings of structure.

Special Safety Equipment

Special safety equipment needed for the Level III inspection of an intake/outlet works are listed in the standards developed for the Standard Inspection of Concrete Dams.

Entry into an intake/outlet works structure or conduit requires the use of a protective harness with attached safety rope.

Approved safety life vests must be worn by all inspection personnel when using boats for inspection purposes or when walking across high spillway crests.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 6 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.02.05-6

Recommended Inspection Frequency

Intake/Outlet Works - as needed basis

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993

2. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977

3. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974

4. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983

5. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987

6. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987

7. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987

8. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 7**

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.02.05-7

Application

This guide has been prepared to identify the purpose of a Level III inspection of gate structure operations at the intake/outlet works.

The results of the Level III inspection can be used to trigger necessary repair or remedial measure activities.

Special Safety Requirements

Operating the intake/outlet works gate will temporarily affect the downstream environment of the dam. Inspection of gate operations must be performed only after prior notification of the Facility Manager or person responsible for the dam structure, and the inspection personnel must check in with the above personnel upon completion of the inspection process.

Inspection of gate operations requires a minimum of two personnel at the gate control system site. The second person should be one who is completely familiar with the operation of the gate structure and actually operates the gate during the inspection.

Inspection Action

1. Two personnel present at the gate control system site.

2. Review operating instructions for the gate.

3. Partially open the gate (mechanical or electrical operated) by appropriate controlling of the gate control system. Allow any debris caught by the gate to be washed through the intake/outlet works system.

4. Open the gate to the "full open" position unless it is necessary to limit gate travel because of low reservoir level. Allow water to pass through the intake/outlet works system and clear any debris from the outlet conduit or stilling basin. Observe water flow exiting the outlet conduit. The gate should be left fully open for no longer than 60 seconds.

5. Close the gate structure completely. Observe exit of outlet conduit for any continued flow. Notify the Facility Manager immediately if unable to close the gate.

** *This Guide Sheet is triggered by conditions beyond the inspection process such as time, age, or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 7** (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-II 15.02.05-7**

Special Tools and Equipment Requirements

Equipment designated for use in gate operations

Special Safety Equipment

No special safety requirements are needed for the Level III inspection of intake/outlet work gate operations beyond the requirements listed in the standards developed for the Standard Inspection of Concrete Dams.

Recommended Inspection Frequency

Gate Operations, Intake/Outlet Works - 1 year intervals

References

1. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982.

2. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

3. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

4. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

5. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

6. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987

** *This Guide Sheet is triggered by conditions beyond the inspection process such as time, age, or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 8

COMPONENT: RESERVOIR
CONTROL NUMBER: GS-III 15.02.06-8

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of observable defects recorded in Level I or Level II defect observations of the reservoir.

Whereas the purpose of the Level I and II inspections was to record the observable defects in or surrounding the reservoir, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam and appurtenant works.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multi-disciplined team of engineers experienced in the design and construction of concrete dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing defect condition or to require continued monitoring of existing deficiency conditions in or around the reservoir.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III inspection. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Concrete Dams.

Inspection Action

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 8 (Continued)

COMPONENT: RESERVOIR
CONTROL NUMBER: GS-III 15.02.06-8

Inspection Action (Continued)

2. Perform inspection of the pertinent component where observed defects that triggered a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimates for required maintenance or remedial repair measures, if applicable.

Level III advanced test and inspection methods may be required for several Level I and II defect conditions observed in a reservoir system. Level III advanced test or inspection methods and associated observed defects include, but are not limited to the following:

Advanced Test or Inspection Method	Applicable Observed Defects
dye testing	seepage, sinkholes
soil borings	slope instability, settlement, undermining, erosion, sinkholes
laboratory tests on soil samples (strength tests, moisture content, consolidation tests, etc.)	slope instability
infrared thermography	voids, seepage, sinkholes
ground probing radar	voids, sinkholes
slope inclinometers	slope stability, measurement monument,
slope movement monuments	slope movement, slope stability
flow measurement readings	seepage, leakage
underwater inspection	evaluating whirlpool conditions

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 8 (Continued)

COMPONENT: RESERVOIR
CONTROL NUMBER: GS-III 15.02.06-8

Special Instructions

Review as-built and design drawings of structure.

Special Tools & Equipment Requirements

Equipment designated in Level I inspections
Survey Level and rod
Standard testing equipment required to perform the non-standard test or investigation method

Special Safety Equipment

Special safety equipment needed for the Level III inspection of a reservoir are listed in the standards developed for the Standard Inspection of Concrete Dams.

Approved safety life vests must be worn by all inspection personnel when using boats for inspection purposes.

Recommended Inspection Frequency

Reservoir - as needed basis

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993.

2. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

3. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

4. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

5. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 8 (Continued)

COMPONENT: RESERVOIR
CONTROL NUMBER: GS-III 15.02.06-8

References (Continued)

6. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

7. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

8. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 9

COMPONENT: DOWNSTREAM CHANNEL
CONTROL NUMBER: GS-III 15.02.07-9

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of defects recorded in Level I or Level II defect observations of the downstream channel.

Whereas the purpose of the Level I inspection of the downstream channel was to record the observable defects within a 1/4 to 1/2 mile distance downstream of the dam, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multi-disciplined team of engineers experienced in the design and construction of concrete dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing deficiency conditions or to require continued monitoring of existing deficiency conditions along the downstream channel.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III test and inspection method. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Concrete Dams.

Inspection Action

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 9 (Continued)

COMPONENT: DOWNSTREAM CHANNEL
CONTROL NUMBER: GS-III 15.02.07-9

Inspection Action

2. Perform inspection of the pertinent components where observed defects that triggered a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance, or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimate for required maintenance or remedial repair measures, as applicable.

Level III advanced inspection methods may be required for several different Level I defect conditions observed along the downstream channel. Level III advanced test or inspection methods and associated observed defects for a downstream channel include, but are not limited to the following:

Advanced Test or Inspection Method	Applicable Observed Defects
1. backhoe excavations	soft zones, slope instability, sedimentation accumulation
2. dye testing	seepage
3. piezometer installation	slope instability, seepage, wet zones
4. relief wells	wet zones, seepage
5. soil borings	slope instability, erosion

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 9 (Continued)

COMPONENT: DOWNSTREAM CHANNEL
CONTROL NUMBER: GS-III 15.02.07-9

Advanced Test or Inspection Method	Applicable Observed Defects
6. laboratory tests on soil samples (strength tests, moisture content, consolidation tests, etc.)	slope instability
7. infrared thermography	voids, sinkholes, seepage, poor drainage
8. ground probing radar	voids
9. slope inclinometers	slope stability
10. slope movement monuments	slope movement, slope stability
11. erosion survey monuments	extensive or rapidly progressing erosion in downstream channels
12. flow measurement readings	seepage, leakage

Special Instructions

Review as-built and design drawings of structure.

Special Tools and Equipment

Equipment designated in Level I inspections
Survey Level and rod
Navigable boat with approved life preservers
Industry required testing equipment needed to perform the advanced investigation method chosen

Special Safety Equipment

Special safety equipment needed for the Level III inspection of the downstream channel are listed in the standards developed for the Standard Inspection of Concrete Dams.

Recommended Inspection Frequency

Reservoir - As needed basis

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 9 (Continued)

COMPONENT: DOWNSTREAM CHANNEL
CONTROL NUMBER: GS-III 15.02.07-9

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993.

2. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

3. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

4. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

5. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

6. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

7. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

8. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 10**

COMPONENT: POWER STRUCTURE
CONTROL NUMBER: GS-III 15.02.08-10

Application

This guide has been prepared to identify the purpose of a Level III inspection of gate structure operations of the Power Structure.

The results of the Level III inspection can be used to trigger necessary repair or remedial measure activities.

Special Safety Requirements

Operating the power structure gate will temporarily affect the downstream environment of the dam. Inspection of gate operations must be performed only after prior notification of the Facility Manager or person responsible for the dam and power structure, and the inspection personnel must check in with the above personnel upon completion of the inspection process.

Inspection of gate operations requires a minimum of two personnel at the gate control system site. The second person should be one who is completely familiar with the operation of the gate structure and actually operates the gate during the inspection.

Inspection Action

1. Two personnel present at the gate control system site.

2. Review operating instructions for the gate.

3. Partially open the gate (mechanical or electrical operated) by appropriate controlling of the gate control system.

4. Open the gate to the "full open" position unless it is necessary to limit power structure gate travel because of low reservoir level. Allow water to pass through the power structure gate system and clear any debris from the tail race. Observe water flow exiting the tail race. The gate should be left fully open for no longer than 60 seconds.

5. Close the gate structure completely. Observe tail race for any continued flow. Notify the Facility Manager immediately if unable to close the gate.

** *This Guide Sheet is triggered by conditions beyond the inspection process such as time, age, or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 10 (Continued)**

COMPONENT: POWER STRUCTURE
CONTROL NUMBER: GS-II 15.02.08-10

Special Tools and Equipment Requirements

Equipment designated for use in gate operations

Special Safety Equipment

No special safety requirements are needed for the Level III inspection of intake/outlet work gate operations beyond the requirements listed in the standards developed for the Standard Inspection of Concrete Dams.

Recommended Inspection Frequency

Gate Operations, Intake/Outlet Works - 1 year intervals

References

1. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982.

2. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

3. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

4. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

5. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

** *This Guide Sheet is triggered by conditions beyond the inspection process such as time, age, or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 11

COMPONENT: POWER STRUCTURES
CONTROL NUMBER: GS-III 15.02.08-11

Application

This guide has been prepared to identify the purpose of selection of a Level III Key 11 during inspection of power structures during a Level I concrete dam inspection.

The purpose of the Level I inspection of the power structure is to identify defects which are detrimental to the safe operation or structural integrity of the dam. It is not intended that inspection of the power structure by a Level I concrete dam inspector should be performed in lieu of a Level I inspection of the building structure itself or as an operating power facility. These inspections must be performed by inspectors experienced in the design and operation of such facilities.

Selection of a Level III Key 11 identifies that existing conditions that affect the concrete dam are such that performance of a Power Structures inspection should be performed by appropriate inspection personnel.

Special Safety Requirements

Special safety requirements are as set forth in the written standards for Building Substructure, Building Superstructure, Building Exterior, Building Electrical, an electrical Distribution.

Inspection Items

Inspection items shall be as set forth in the written standards for Building Substructure, Building Superstructure, Building Exterior, Building Electrical, and Electrical Distribution.

Special Tools and Equipment Requirements

Special tools and equipment requirements shall be as set forth in the written standards for Building Substructure, Building Superstructure, Building Exterior, Building Electrical, and Electrical Distribution.

Special Safety Equipment

Special safety requirements required for a Level I inspection of a power structure facility is found in the written standards for Building Superstructure, Building Exterior, Building Electrical, and Electrical Distribution.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 11 (Continued)

COMPONENT: POWER STRUCTURES
CONTROL NUMBER: GS-III 15.02.08-11

Recommended Inspection Frequency

Power Structures - as needed basis; inspection frequency as required for Buildings-Substructure; Buildings-Superstructure; Building Exterior; Building-Electrical; Electrical Distribution; and Tunnels

References

See written standards for Building Substructure, Building Superstructure, Building Exterior, Building Electrical, and Electrical Distribution.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 12

COMPONENT: ACCESS ROAD
CONTROL NUMBER: GS-III 15.02.09-12

Application

This guide has been prepared to identify the Level III Key 12 during a Level I concrete dam inspection.

Level I concrete dam inspection includes observing the condition of access roads or dam related bridges including pavement, drainage ditches, and bridge structure for access roads located along the crest of the embankment dam or where bridging crosses the downstream channel. The purpose of the Level I concrete dam inspection is to ensure that the access roadway is clear for emergency vehicular traffic; to observe if drainage ditches along the sides of the access roadway are free of debris and show no signs of slope instability which encroach on the access road; and to observe general bridge conditions to ensure that passage is achievable.

It is not intended that inspection of the pavement or bridges by a Level I concrete dam inspector should be performed in lieu of a Level I inspection of the pavement or bridge structure itself. These inspections must be performed by inspectors experienced in the design and operation of such structures.

Selection of a Level III Key 12 for pavement or for bridges indicates that obvious signs of deterioration were observed and that a Level I inspection should be performed to accurately measure and identify those conditions by appropriate inspection personnel.

Special Safety Requirements

Special safety requirements are as set forth in the written standards for bridges and pavements.

Inspection Items

Inspection items shall be as set forth in the written standards for bridges and pavements.

Special Tools and Equipment Requirements

Special tools and equipment requirements shall be as set forth in the written standards for bridges and pavements.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 12 (Continued)

COMPONENT: ACCESS ROAD
CONTROL NUMBER: GS-III 15.02.09-12

Special Safety Equipment

Special safety requirements required for a Level I inspection of bridges and access roads are found in the written standards for bridges and pavements, respectively.

Recommended Inspection Frequency

Access Road - as needed basis; inspection frequency as required for Bridges and Pavements/Improved Surfaces

References

See written standards for bridges and pavements.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY 13*

SUBSYSTEM: CONCRETE DAM AND APPURTENANT WORKS
CONTROL NUMBER: GS-III 15.02-13*

Application

This guide has been prepared to identify the purpose of a regularly scheduled Level III inspection of concrete dams and appurtenant structures.

Whereas the purpose of the Level I inspection was to record the condition of observable defects at readily accessible components of the dam and appurtenant works, the Level III inspection is performed to provide a thorough systematic evaluation of the physical condition of the dam and all appurtenant works, and an assessment of the safety and stability of the project structures.

The Level III inspection also includes inspection of sections of the intake/outlet works which may require dewatering or work performed by others prior to actual inspection, and making a visual inspection of the floodplain downstream of the dam to determine the existing land uses occupying the 100-year floodplain.

This type of Level III inspection should be performed on a regularly scheduled basis. The inspection should be performed by an engineer or multi-disciplined team of engineers experienced in the design and construction of concrete dams.

The written standards developed for Level I inspection can be used as a guide or outline to be followed during the regularly scheduled Level III inspection. The primary difference between the two types of inspections is that an assessment of observed condition with respect to degree of severity and to the stability and safety of the dam is made and an assessment can be made to indicate which maintenance or remedial measure work is the most important to be completed for the particular project site.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy to correct existing deficiency conditions or result in continued monitoring of existing conditions of the concrete dam and appurtenant works.

Special Safety Equipment

Special safety equipment needed for the engineering inspection of components of a concrete dam and appurtenant works are listed in the standards developed for the Standard Inspection of Concrete Dams.

Entry into an intake/outlet works structure or conduit require the use of a protective harness with attached safety rope.

** This Guide Sheet is not referenced by a Key, but may be "triggered" by conditions beyond the inspection process such as time, age, or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY 13* (Continued)

SUBSYSTEM: CONCRETE DAM AND APPURTENANT WORKS
CONTROL NUMBER: GS-III 15.02-13*

Approved safety life vests must be worn by all inspection personnel when using boats for inspection purposes or when walking across high spillway crests.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for Standard Inspection of Concrete Dams.

For entry into any intake/outlet works structure, operation of any gate facility, or inspection work item performed by boat, the inspection team shall consists of a minimum of two personnel. Any person entering the intake/outlet works structure must have a safety rope and protective harness, and other safety equipment or measures as required by OSHA and all other agencies having jurisdiction.

Inspection Action

1. Prior to performing the field inspection, review all past records concerning the dam if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

2. Perform inspection of all pertinent components listed in the written standards for a Level I inspection of a concrete dam and appurtenant works.

3. Inspect any components of the intake/outlet works which require dewatering, entrance into a vertical drop shaft or intake/outlet conduit, or work to be performed by others prior to gaining access to the structure(s).

4. Inspect the floodplain downstream of the dam and determine any changes in the existing land uses occupying the 100-year floodplain.

5. Identify whether particular observed defects need to be further investigated per non-standard test or inspection methods as set forth in GS-III 15.02.01-1 through GS-III 15.02.07-1, or if continued observation is appropriate. Engineer(s) to identify and plan appropriate non-standard test or inspection method and supervise performance of the inspection when applicable.

** This Guide Sheet is not referenced by a Key, but may be "triggered" by conditions beyond the inspection process such as time, age, or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY 13* (Continued)

SUBSYSTEM: CONCRETE DAM AND APPURTENANT WORKS
CONTROL NUMBER: GS-III 15.02-13*

Inspection Action (Continued)

7. Make an assessment of the importance of individual defects observed at the dam site. Indicate priorities for any required maintenance, additional investigations, and/or remedial measure work.

8. Assess the stability and safety of the dam.

9. Prepare cost estimates for advanced test or inspection methods to determine the cause and extent of observable defect(s) which may impact the stability of the dam.

10. Prepare cost estimates for required maintenance or remedial repair measures, as applicable.

Special Tools and Equipment Requirements

Equipment designated in Level I inspections
Survey Level and rod
Navigable boat with approved life preservers
Standard testing equipment required to perform the non-standard test or investigation method
Protective harness with safety rope

Recommended Inspection Frequency

Regularly Scheduled Level III Inspection - 5 year intervals

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993.

2. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977.

** This Guide Sheet is not referenced by a Key, but may be "triggered" by conditions beyond the inspection process such as time, age, or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY 13* (Continued)

SUBSYSTEM: CONCRETE DAM AND APPURTENANT WORKS
CONTROL NUMBER: GS-III 15.02-13*

References (Continued)

3. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974.

4. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983.

5. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987.

6. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987.

7. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987.

8. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency, FEMA 145, August 1987

** This Guide Sheet is not referenced by a Key, but may be "triggered" by conditions beyond the inspection process such as time, age, or repeated service calls.*

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 14

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.02.05-14

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of observable defects recorded in Level I or Level II defect observations of the intake/outlet works.

Whereas the purpose of the Level I and II inspections was to record the observable defects at readily accessible components of the intake/outlet works, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam and the intake/outlet works.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multi-disciplined team of engineers experienced in the design and construction of embankment dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing defect condition or to require continued monitoring of existing deficiency conditions at the intake/outlet works.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III inspection. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Embankment Dams.

For entry into any intake/outlet works structure, operation of any gate facility, or inspection work item performed by boat, the inspection team shall consists of a minimum of two personnel. Any person entering the intake/outlet works structure must have a safety rope and protective harness, and other safety equipment or measures as required by OSHA and all other agencies having jurisdiction.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 14 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.02.05-14

Inspection Actions

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

2. Perform inspection of the pertinent component where observed defects that triggered a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimates for required maintenance or remedial repair measures, if applicable.

Level III advanced test and inspection methods may be required for many different Level I and II defect conditions observed in an intake/outlet work system. Level III advanced test or inspection methods and associated observed defects include, but are not limited to the following:

Advanced Test or Inspection Method	Applicable Observed Defects
1. dye testing	seepage
2. soil borings	undermining, erosion
3. infrared thermography	voids, seepage, poor drainage

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 14 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.02.05-14

Advanced Test or Inspection Method	Applicable Observed Defects
4. ground probing radar	voids
5. flow measurement readings	seepage, leakage
6. geophysical surveys (sonic, downhole and crosshole arrays, seismic reflection, refraction, etc.)	undermining
7. underwater inspection	closing intake structure, inspection of intake structure, evaluating undermining conditions

Special Tools and Equipment

1. Equipment designated in Level I inspections
2. Survey Level and rod
3. Navigable boat with approved life preservers
4. Standard testing equipment required to perform the non-standard test or investigation method

Special Instructions

Review as-built and design drawings of structure.

Special Safety Equipment

Special safety equipment needed for the Level III inspection of an intake/outlet works are listed in the standards developed for the Standard Inspection of Embankment Dams.

Entry into an intake/outlet works structure or conduit requires the use of a protective harness with attached safety rope.

Approved safety life vests must be worn by all inspection personnel when using boats for inspection purposes or when walking across high spillway crests.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 14 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.02.05-14

Recommended Inspection Frequency

Intake/Outlet Works - as triggered by Level I inspection observations

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993

2. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982

3. EM 1110-2-1902, Stability of Earth and Rock-Fill Dams, April 1, 1970, Includes Change 1

4. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977

5. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974

6. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983

7. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987

8. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987

9. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987

10. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency FEMA 145, August 1987

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 15

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.02.05-15

Application

This guide has been prepared to identify the purpose of a Level III inspection and its more sophisticated test and inspection methods which may be appropriate to determine the cause and/or extent of observable defects recorded in Level I or Level II defect observations of the intake/outlet works.

Whereas the purpose of the Level I and II inspections was to record the observable defects at readily accessible components of the intake/outlet works, this Level III inspection is performed to provide a thorough systematic evaluation of the observed defect and to make an assessment of it's effects, if left unchecked, on the safety, durability and stability of the dam and the intake/outlet works.

The Level III inspection should be performed when prompted by the results of a Level I or II inspection. The inspection should be performed by an engineer or multi-disciplined team of engineers experienced in the design and construction of embankment dams.

The results of the Level III inspection will be used to develop maintenance or remedial measure work strategy that will correct the existing defect condition or to require continued monitoring of existing deficiency conditions at the intake/outlet works.

In general, appropriate advanced inspection methods will be identified, recommended, and performed by or under the supervision of the inspection engineer personnel as part of the Level III inspection. Advanced inspection methods will be assigned only after the assessment of defect conditions observed during a Level I or II inspection.

Special Safety Requirements

Special safety requirements are as set forth in the standards developed for the Standard Inspection of Embankment Dams.

For entry into any intake/outlet works structure, operation of any gate facility, or inspection work item performed by boat, the inspection team shall consists of a minimum of two personnel. Any person entering the intake/outlet works structure must have a safety rope and protective harness, and other safety equipment or measures as required by OSHA and all other agencies having jurisdiction.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 15 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.02.05-15

Inspection Actions

1. Prior to making a field inspection of the observed defect, review all past records concerning the dam and the defective component if available. These records may include pre-construction investigation records, design criteria and analysis records, available construction records, previous periodic maintenance inspection records, reservoir level records, movement monument survey records, and photographs taken during initial construction and subsequent inspections.

2. Perform inspection of the pertinent component where observed defects that triggered a Level III inspection are listed.

3. Make an assessment of the importance of individual defects observed for a given component at the dam site. Indicate priorities for any required maintenance or remedial measure work.

4. Identify whether particular observed defects need additional or continued observation.

5. Assess the stability and safety of the dam.

6. Prepare final cost estimate for advanced inspection methods required to determine the cause and extent of the observed defect.

7. Prepare cost estimates for required maintenance or remedial repair measures, if applicable.

Level III advanced test and inspection methods may be required for many different Level I and II defect conditions observed in an intake/outlet work system. Level III advanced test or inspection methods and associated observed defects include, but are not limited to the following:

Advanced Test or Inspection Method	Applicable Observed Defects
1. dye testing	seepage
2. soil borings	undermining, erosion
3. infrared thermography	voids, seepage, poor drainage

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 15 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.02.05-15

Advanced Test or Inspection Method	Applicable Observed Defects
4. ground probing radar	voids
5. flow measurement readings	seepage, leakage
6. geophysical surveys (sonic, downhole and crosshole arrays, seismic reflection, refraction, etc.)	undermining
7. underwater inspection	closing intake structure, inspection of intake structure, evaluating undermining conditions

Special Tools and Equipment

1. Equipment designated in Level I inspections
2. Survey Level and rod
3. Navigable boat with approved life preservers
4. Standard testing equipment required to perform the non-standard test or investigation method

Special Instructions

Review as-built and design drawings of structure.

Special Safety Equipment

Special safety equipment needed for the Level III inspection of an intake/outlet works are listed in the standards developed for the Standard Inspection of Embankment Dams.

Entry into an intake/outlet works structure or conduit requires the use of a protective harness with attached safety rope.

Approved safety life vests must be worn by all inspection personnel when using boats for inspection purposes or when walking across high spillway crests.

LEVEL III INSPECTION METHOD GUIDE SHEET

LEVEL III GUIDE SHEET - KEY NO. 15 (Continued)

COMPONENT: INTAKE/OUTLET WORKS
CONTROL NUMBER: GS-III 15.02.05-15

Recommended Inspection Frequency

Intake/Outlet Works - as triggered by Level I inspection observations

References

1. U.S. Army Corps of Engineers, Kansas City District, Guidebook - General Information for Sponsors of Flood Protection Projects Constructed by the Corps of Engineers, Reprinted July 1993

2. EM 1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations, May 10, 1982

3. EM 1110-2-1902, Stability of Earth and Rock-Fill Dams, April 1, 1970, Includes Change 1

4. Design of Small Dams, United States Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1977

5. Engineering Foundation Conference Proceedings, Safety of Small Dams, American Society of Civil Engineers, August 1974

6. Safety of Existing Dams, Evaluation and Improvement, Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, National Academy Press, 1983

7. Rules For Construction and Maintenance of Dams, Illinois Department of Transportation Division of Water Resources, Revised February 1, 1987

8. Guidelines and Forms For Inspection of Illinois Dams, Illinois Department of Transportation Division of Water Resources, February 1987

9. Dam Safety Guidebook, Illinois Edition, Prepared for State of Illinois and Federal Emergency Management Agency by STS Consultants, Ltd., 1987

10. Dam Safety: An Owner's Guidance Manual, Federal Emergency Management Agency FEMA 145, August 1987

APPENDIX A

ABBREVIATIONS

D/S	Downstream
EA	Each
FT	Feet
GPM	Gallons Per Minute
GS-II	Guide Sheet, Level II Inspection Method
GS-III	Guide Sheet, Level III Inspection Method
IN	Inches
LF	Linear Feet
SF	Square Feet
UOM	Unit of Measure
U/S	Upstream
w/	with
w/o	without
waterlne	waterline
<	Less Than
>	Greater Than
= <	Equal to or Less Than
= >	Equal to or Greater Than
@	at
"	Inch or Inches
'	Foot or Feet

APPENDIX B

GLOSSARY
DESCRIPTION OF EMBANKMENT AND CONCRETE DAM TERMS

Abutment	The contact point between the ends of the dam or spillway and the natural ground. Right and left abutments are those respective sides of an observer when viewed looking downstream.
Approach Channel	A natural or excavated channel extending from the reservoir to the control structure of a spillway or emergency spillway. (May not be applicable for all dams).
Appurtenant Works	The structures or machinery auxiliary to dams which are built to operate and maintain dams, such as outlet works, spillway, powerhouse, tunnels, etc.
Arch Dam	A concrete or masonry dam that is curved in plan so as to transmit the major part of the water load to the abutments.
Berm	A horizontal step or bench in the sloping profile of an embankment dam.
Breach	A break, gap or opening (failure) in a dam which releases impounded water.
Buttress Dam	A dam consisting of a watertight upstream face supported at intervals on the downstream side by a series of buttresses. Buttress Dams can take many forms.
Chute (Spillway)	A spillway whose discharge is conveyed from the reservoir to the downstream river level through an open chute channel, placed either along a dam abutment or through a saddle, regardless of the control structure used to regulate flow. The chute generally extends from the control structure to a stilling basin or terminal structure.
Concrete Dam	Any dam constructed of concrete.
Construction Joint	The interface between two successive placings or pours of concrete where bond, not permanent separation, is intended.
Control System (Spillway or Intake/Outlet Works)	For a spillway, the control structure is a device which regulates and controls the outflows from the reservoir. This control limits or prevents outflows below fixed reservoir levels, and it also regulates releases when the reservoir rises above that level. The control structure may consist of a sill, weir, orifice, tube, or pipe and may or may not be gated. For intake/outlet works, the control structure is generally a gated structure which regulates and controls outflow through the intake/outlet structure.

APPENDIX B

Core	A zone of material of low permeability in an embankment dam.
Crest (Concrete)	The crest of a concrete dam is the top surface of the dam structure. The width depends on the height and importance of the dam, possible roadway requirements, and practicability of construction.
Crest (Embankment)	The crest of an embankment dam is the top surface of the embankment. The width depends on the nature of embankment materials and minimum allowable percolation distance through the embankment at normal reservoir water level; height and importance of the dam, possible roadway requirements, and practicability of construction.
Crest (Spillway)	A spillway crest is highest part of the spillway control structure.
Cutoff Wall	A wall of impervious material (e.g. concrete, asphaltic concrete, steel sheet piling, etc.) built into the foundation to reduce seepage under the dam.
Dam	A barrier built for impounding or diverting the flow of water.
Dewatering Operations	Operations required to lower the reservoir level to the lowest possible level affected by the control structure or to some intermediate level desired for operation of the dam.
Downstream Channel	The original or excavated river channel or streambed where water discharged through the dam or spillway flows downstream of the dam.
Drain, Layer or Blanket	A layer of pervious material in an embankment dam to facilitate drainage or to relieve pore pressure. Includes toe drain and chimney drain.
Drawdown	The resultant lowering of reservoir level due to release of water from the impoundment.
Drop Inlet Spillway	A spillway where water enters over a horizontally positioned lip, drops through a vertical or sloping shaft, and then flows to the downstream river channel through a horizontal or near horizontal conduit or tunnel.
Drop Shaft	A vertical drop shaft or stack of pipe risers extending from the crest of the embankment to the intersecting intake/outlet works passing through the embankment.
Embankment	Fill material, usually soil or rock, placed with sloping sides.
Embankment Dam	Any dam constructed of excavated natural soil and/or rock materials or of industrial waste materials.
(Homogeneous) Embankment Dam	An embankment dam constructed of essentially similar material throughout, except for possible inclusion of drains.

APPENDIX B

(Zoned) Embankment Dam	An embankment dam divided into zones of materials having different physical properties.
Emergency Warning Plan	A predetermined plan of action to be taken to reduce the potential for property damage and loss of life.
Failure	An incident resulting in the uncontrolled release of water from a dam.
Flashboards	Length of timber, concrete or steel placed on the crest of a spillway to raise the retention water level but that may be quickly removed in the event of a flood either by a tripping device or by deliberately designed failure of the flashboards or their supports.
Freeboard	The vertical distance between a stated water level and the top of a dam. "Net freeboard", "Dry freeboard", "Flood freeboard" or "Residual freeboard" is the vertical distance between the estimated maximum water level and the top of a dam. "Gross freeboard" or "Total freeboard" is the vertical distance between the maximum planned controlled retention water level and the top of a dam.
Gallery	A passageway within the body of a dam or abutment, or a long and narrow hall.
Gate or Valve	A device in which a leaf or member is moved across the waterway to control or stop the flow of water.
Gravity Dam	A dam constructed of concrete or masonry that relies on its weight for stability.
Impoundment	Water or wastewater held back by a dam.
Intake Structure (for Outlet Works)	A structure forming the entrance into the outlet works which may include control devices. It also supports necessary auxiliary appurtenances such as trash racks, fish screens, and bypass devices and may include provision for installation of bulkhead or stoplog closure devices. The intake structure may either be submerged or extended as a tower to some height above the maximum reservoir water surface, depending on its function. The conduit entrance can be placed vertically, inclined, or horizontally, depending on intake requirements.
Instrumentation	Permanent devices which are installed in or near a dam to allow monitoring of the dam and impoundment. Such instrumentation may include a staff gage, piezometers, observation wells, settlement or alignment points, rain gage, etc.

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Maintenance	The upkeep necessary for efficient operation of dams and appurtenant works. It involves labor and materials, but is not part of alterations or remedial repair measures.
Masonry Dam	Any dam constructed mainly of stone, brick, or concrete blocks that may or may not be joined with mortar. A dam having only a masonry facing should not be referred to as a masonry dam.
Normal Pool Level	For a reservoir with a fixed overflow sill, it is the lowest crest level of that sill. For a reservoir where the outflow is controlled wholly or in part by gates or other means, it is the maximum level at the dam to which water may rise under normal operating conditions, exclusive of any provision for flood surcharge.
Outlet	An opening through which water can freely discharge for a particular purpose from an impoundment.
Outlet Channel (Discharge Channel)	Flow released through the control structure usually is conveyed to the streambed below the dam in a discharge or outlet channel. The conveyance structure can consist of an open channel excavated along the ground surface, a closed cut-and-cover conduit placed through or under a dam, or a tunnel excavated through an abutment.
Penstock (Power Structure)	A pipeline or pressure shaft leading from the headrace or reservoir to the turbines.
Phreatic Surface	The upper surface of saturation in an embankment.
Power Structure	Power plant structure built as part of, or adjacent to a dam. (For purposes of this document, a power structure will only be inspected if it is related to the safe operation or structural integrity of the dam).
Repair (or Remedial Measure)	A method to essentially restore a dam to its approved design condition.
Reservoir	An artificial lake, basin, or tank in which water can be stored.
Reservoir Rim	The intersection of the water level impounded in the reservoir and the surrounding slopes. The rim also includes any slopes above the maximum reservoir level which drain into the reservoir.
Riprap	A layer of large stones, broken rock or precast blocks placed in a random fashion on the upstream and sometimes downstream slope of an embankment dam, on a reservoir shore, or on the sides of a channel as a protection against wave and ice action.

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Slopes (Embankment)	Embankment slopes are the slopes required for stability of the embankment on a stable foundation. The design slopes of an embankment may vary widely, depending on the characteristics of the materials available for construction, foundation conditions, and the height of the structure.
(Upstream Slope)	The upstream slope is located on the reservoir side (or upstream side) of the embankment. The upstream slope may vary from 2(H):1(V) to as flat as 4(H):1(V) for stability; usually it is 2.5(H):1(V) to 3(H):1(V). A berm is often provided at an elevation slightly below the maximum drawdown of the reservoir water surface to form a base for the upstream slope protection. The upstream slope is often steepened above the elevation where water is stored.
(Downstream Slope)	The downstream slope is located on the downstream side of the embankment. The slopes of an embankment dam depend on the type of dam and the characteristics of the materials used for construction. Usual downstream slopes for small earthfill dams are 2(H):1(V) for dams with a downstream pervious zone, and 2.5(H):1(V) for dams where the embankment is impervious.
Spillway System	A structure over or through which flows are discharged. If the flow is controlled by gates, it is considered a controlled spillway; if the elevation of the spillway crest is the only control, it is considered an uncontrolled spillway.
(Emergency Spillway)	A secondary spillway designed to operate only during exceptionally large floods.
(Principal Spillway)	The main spillway for normal and flood flows.
Stilling Basin	A basin constructed to dissipate the energy of fast flowing water, such as from a spillway or bottom outlet, and to protect the river bed from erosion.
Stoplogs	Logs or timbers, steel or concrete beams placed on top of each other with their ends held in guides on each side of a channel or conduit.
Tail Race (Power Structure)	The tunnel, channel, or conduit that conveys the discharge from a powerplant turbine to the river.
Tailwater Level	The level of water in the tailrace at the nearest free surface to the turbine or in the discharge channel immediately downstream of the dam.
Toe of Dam	The junction of the downstream face of a dam with the ground surface.
Toe of Embankment	The junction of the downstream slope of a dam with the ground surface.

APPENDIX B

Top Thickness	The thickness of a dam at the level of the top of the dam. In general, the term "thickness" is used for gravity and arch dams and the term "width" is used for other dams.
Trash Rack	A structure of metal or concrete bars located in the waterway at an intake to prevent the entry of floating or submerged debris.
Valve	A device fitted to a pipeline or orifice in which the closure member is either rotated or moved transversely or longitudinally in the waterway so as to control or stop the flow.

APPENDIX B

GLOSSARY
DESCRIPTION OF EMBANKMENT AND CONCRETE DAM DEFECTS

Abutment	Abutment areas are the contact points between the dam or spillway and the sides of the original valley. These areas should be closely and frequently inspected for any signs of seepage, cracks or erosion. Observation of seepage, cracking, or erosion at this intersection should prompt an immediate Level III inspection to assess the stability of the dam or spillway.
Alkali-Silica Aggregate Reaction	The alkali-silica reaction can occur in concrete containing certain types of aggregate containing reactive forms of silica and cement in the concentrations required to produce such a reaction. The research is irreversible and may continue for many years in hardened concrete, although the intensity of the reaction generally declines with passage of time. Observable surface defects associated with the alkali-silica reaction include the well known fracture pattern, heaving, joint displacement, and spalling. Most test results conclude that the expansion of concrete in dams caused by alkali-silica reaction generally results in a retrogression of compressive strength and modulus of elasticity. The rate of reduction in quality is often rapid during the first period of years following construction, and then gradually declines until there is little reduction in strength after many years following construction. Notable exceptions have occurred, however, where little if any reduction in concrete strength occurred even though serious surface cracks and movement have occurred.
Animal Damage	Damage due to animals can include animal burrows or worn paths eroded on the slopes of an embankment dam or on the slopes of the abutments. Animal burrows, particularly in the upstream slope, can result in a loss of earth material and water infiltration into the inside of the dam and cause significant erosion or deterioration of the embankment. Worn paths may result in more rapid weathering and erosion channel development. The animals should be removed and the burrows filled in with available soil material on an on-going basis as part of routine maintenance work.

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Animal Habitat	The presence of rodents and other burrowing or dam-building animals at an embankment dam site can result in embankment stability problems or ponding of tailwater against the downstream embankment slope. Animal habitat which obstructs flow through the outlet conduits or downstream channel should be cleared and removed as part of routine maintenance work. If rodents become a nuisance, population control measures in compliance with local regulations may be required.
Beach Erosion	Erosion of the reservoir rim along the waterline is termed beach erosion. Erosion generally occurs as a result of wave action against erodible materials on the beach. Depending on the slope of the reservoir rim, extensive beach erosion can cause instability of the reservoir rim slopes or a potential conduit for outfall from the reservoir to by-pass the dam. Beach erosion conditions can be particularly observed during periods of low reservoir level. Beach erosion protection measures should be placed or eroded material replaced as necessary as part of routine maintenance work to protect the shores from further erosion.
Benching	Benching of the upstream slope of an embankment dam can result from erosion of dissimilar materials by wave action. The benching of the upstream slope can have the appearance of a berm notched into the slope. If such condition intercepts a more permeable layer of fill placed within the embankment, a direct passageway of seepage through the embankment can develop. The benching condition should be closely observed and the areal extent and location of benching should be recorded during the inspection. Slope protection measures should be placed to protect the benched area as part of the routine maintenance work and/or the effectiveness of the existing slope protection measure should be re-evaluated.

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Concrete Condition	Concrete surfaces should be inspected for observance of signs of deterioration, erosion and cavitation, as well as the development of cracks and spalling. Such signs can lead to further signs of deterioration of the structure over a period of time. Where observed, poor condition concrete surfaces should be removed and patched to protect the structural integrity of concrete parts of the dam.
Construction Joints	Construction joints (both in concrete structures and pipe joints) should be periodically checked for tightness and kept water tight. Displaced construction joints can be a sign of movement of the particular structure, erosion occurring beneath or behind the particular structure, or a source for leakage and water infiltration/exfiltration. Open joints should be filled with a flexible waterproof joint compound as part of routine maintenance operations. Open joints in intake or outlet conduits or vertical dropshafts may require the use of watertight cement or injection of cement or chemical grout to stop leakage.
Erosion Protection (Slope Protection)	Erosion protection of embankment dams generally consists of the use of stone riprap, concrete, asphaltic concrete, vegetation cover and occasionally geotextile fabric to provide slope protection against surface runoff, wave action, and traffic. The mode of erosion protection should be uniformly maintained along the entire height of the embankment slopes and along the crest of the embankment. Riprap on both embankment slopes should be maintained at the original line and grade. Routine inspections should include the scrutinization for depressed areas, dense piles of riprap bordered by barren areas, murky water along the waterline, and for erosion at the top of the embankment slopes. If erosive conditions or observed, then the slope protection measure should be re-distributed or added to alleviate the problem. Erosion protection at concrete dams generally consists of the use of the measures listed above to provide slope protection against surface runoff along downstream or outlet channels.

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Gate Operations	Any gate associated with embankment or concrete dams (intake/outlet works, spillway, powerhouse, etc.) should be in proper working order at the time of inspection. If the gate(s) is not functioning satisfactorily, inspection of the mechanical and/or electrical components of the control system should be inspected. Mechanical components should be examined, lubricated and kept free from rust as part of routine maintenance work. Gate machinery should be kept in a clean and efficient operating condition to ensure the drawdown of the reservoir level as needed.
Gate Seals	Spillway or intake/outlet works gates are designed to shut off flow completely through the particular opening. Due to deterioration over time, the seal between the gate and the gate structure may deteriorate and result in leakage even when the gate is in the closed position. Potential problems can include deterioration or breakage of rubber gaskets or stopgap structures along the perimeter of the gate or breakage of the concrete sill at the bottom of the channel.
Landslide	A landslide is a mass movement landform and process involving the downslope transport, under gravitational influence, of soil and rock material en masse. Usually the displaced material moves over a relatively confined zone or surface of shear. Instances have occurred where landslides have fallen into reservoirs, creating high waves which subsequently overtopped the dam. In addition, landslides can create significant impediments to drainage by creating dams in outlet or downstream channels. In most instances, it is assumed that Level I inspections will be restricted to recording the location and approximate size of existing landslides located along the reservoir. Level III inspections should include observation for potential conditions or preliminary signs that a landslide is possible. Advanced test and inspections such as soils borings, inclinometers, or slope movement monuments may be applicable to further assess the potential for landslides to occur.

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Leakage

Leakage is defined as the uncontrolled release of water around or through a gate when in the closed position or the infiltration or exfiltration of water into a conduit, pipe, vertical drop shaft, gate or concrete dam structure. Leakage around a gate structure while closed should be noted during the inspection and an estimate made of the flow rate passing through the gate. Leakage into the conduits should be noted including location, estimate flow rate, and location of leakage with respect to pipe structure (i.e. at construction joint, through pipe wall, etc.). In all instances of leakage, close inspection should be made to observe if soil is being transported in the flowing water: observation of this condition may indicate a piping condition within the dam.

Measurement Monuments

Survey measurement monuments are placed during construction or during subsequent years to monitor vertical and/or horizontal movements of the dam or to form a baseline to monitor rates or erosion along spillway or outlet channels. Such monuments can be used with survey equipment to determine actual locations or elevations, or can be used as relative indicators of slope movement. Defects associated with measurement monuments include missing monuments or occurrences where the monuments are not readily observable due to high vegetation cover or displaced riprap. Missing monuments may be required to be replaced with the assistance of a surveyor.

Metalwork

Metalwork is associated with the condition of metal structures, particularly for gates or metal pipes. Defects which can be observed in these type of structures include rusting or deteriorated steel. Observations should include the extent of rusting (superficial or indicate thickness rust extends into steel surface) and percentage of steel gate or pipe which exhibits rusting or deterioration.

Piping

Piping is an internal erosion condition within an embankment where seepage through the embankment results in the formation of narrow conduits, tunnels, or "pipes" through which soil particles are removed. Continued removal of soil particles can result in a continuous conduit for open flow through the embankment and subsequent potential for embankment instability. Observed piping conditions should be recorded and appropriate personnel informed to perform a Level III inspection. Piping conditions may warrant advanced test and inspection methods, depending on seepage flow rate and amount of soil particles being transported in the seeps.

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Protective Coating	Protective coatings are placed on gates to protect against weathering and exposure to water and air. The protective coating can deteriorate over time, resulting in the gate materials being susceptible to corrosion or rusting. Deteriorated protective gate coatings should be noted and an estimate made of the percentage of the surface area of the gate which does not have a protective coating. A new protective coating can be applied to the entire gate structure at regularly scheduled maintenance intervals.
Rock Falls	Rock fall are a type of slope movement which consists of relatively free falling or precipitous movement of newly detached segments of rock of any size from a cliff or other steep slope and subsequent formation of a detrital pile at the bottom of slope. Rock fall can be triggered by numerous reasons and generally occurs as a sudden movement event. Rock falls can result in exposure of materials more susceptible to weathering; exposure of previously hidden drainage or seepage paths; or forming piles of rock debris which obstruct flow through adjacent channels. Inspection generally consists of recording the location and estimating the size of the rockfall zone. Depending on size and location of the rock fall activity, a Level III inspection may be required.
Sand Boils	Sand boils are the result of hydrostatic pressure built up due to underseepage conditions which pass beneath the dam and escape along the least resistant path back to the surface. The resultant upwelling of hydrostatic pressure can cause sand particles to be propagated to the surface and deposited in a ring around a funnel shaped discharge channel. In cases where the upwelling occurs in a downstream pool, observations may include an upwelling or plume of water rising from the bottom of the pool. Such conditions should be noted including location with respect to toe of dam and require a Level III inspection.
Scour	Scour is underwater erosion caused by the rapid flow and turbulence of water from a spillway or high velocity seepage. Because scour generally occurs underwater, it cannot always be directly observed. Scour can sometimes be identified by an island forming downstream. Probing or soundings can be used to detect scoured areas. Scour beneath a slab is defined as undermining and may cause a concrete slab to crack or break. Observation of scouring conditions warrants a Level III inspection. Due to the difficulty in determining the extent of scouring, underwater inspections or other advanced test and inspection methods may be applicable.

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Sedimentation	Sedimentation is the deposition of fine sediments or sands out of suspension in flowing water. Sedimentation frequently occurs adjacent to a settling basin or pool where water carrying a sediment load under high velocity flow encounters a low energy environment. The resulting stilling or reduction of water velocity in the stilling basin allows the suspended sediment load to be deposited within the downstream channel. Problems can arise when sediment deposit buildup begins to obstruct flow through the downstream channel. Inspections should look for sediment buildup in downstream channels and if present, record the location, extent and thickness of the deposit. Sediment deposit buildup in downstream channels can be cleared out during routine maintenance work.
Seepage	Seepage is the passage of water through and/or underneath the dam or at the contact between the dam and abutment or other structures. Seepage can appear on the downstream slope or face of the dam or along the side slopes of the downstream channel and is frequently noticed due to the growth of cattails or other wet environment vegetation. If a collection system is not provided, erosion channels can typically develop or sections of the slope can become saturated, leading to slumping of the embankment slope. Seepage must be monitored for the presence of fine soil particles being transported with the water from the embankment (piping condition). Seepage conditions should prompt a Level III inspection to assess potential impact to the stability of the dam and may require advanced tests or investigations, or continued monitoring of existing conditions.
Settlement	Settlement of the crest or slopes of an embankment indicates a loss of material or compression of material either within the dam or the foundation. The settlement causes a decrease in elevation of all or a part of the dam. If the settlement is not uniform, surface depressions may appear or surface cracking may result. Observed settlement areas should be identified and amount of vertical settlement determined. Settlement at a given location noted a first time should prompt a Level III inspection and possible establishment of a survey monitoring program.

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Sinkhole	A sinkhole is a funnel-shaped circular depression with an open "throat" allowing water to drain internally into the subterranean materials. The sinkholes typically form in carbonate rocks located near the ground surface where chemical weathering processes has resulted in dissolution of the rock and opening of rock mass discontinuities into interconnected drainage channels. Occasionally, the throats can become clogged with soil material, causing ponding of water in the surface depression. The presence of sinkholes along the reservoir rim can result in unplanned dewatering of the reservoir as active drainage by-passes the dam and control works. A Level III inspection should be performed when sinkholes are observed along the reservoir rim. Remedial measures may include backfilling the sinkhole with concrete or grout. Sinkholes located on the crest or downstream slope of embankments can indicate particularly serious piping conditions within the embankment and should be immediate cause for a Level III inspection.
Slope Stability	Slope stability is the resistance of a natural or artificial slope or other inclined surface to failure by mass movement. Inspection for slope stability requires observation for signs of slope movement which have occurred or in progress, or conditions developing which can lead to slope movement. Slope stability inspection is required along the embankment dam slopes, spillway and emergency spillway channel slopes, and along the downstream and if applicable, outlet channel. Types of slope movement which should be looked for include surface cracking, surface rupture, soil creep, rock fall, sloughing, folding or low amplitude waviness at toe of slope, landslides, etc. Signs of slope instability should be evaluated during a Level III inspection to assess the impact on the stability of the dam or channel.
Sloughing	Sloughing is a form of slope movement where surface materials have slid downhill along a near surface slippage plane, resulting in shallow scars on a hillslope and a pile of detritus at the bottom of slope failure. Sloughing is frequently accompanied by saturation of the soil materials and lubrication of the sliding plane by groundwater. By definition, this type of slope movement is shallow and generally does not affect the stability of the dam. Sloughing along abutments, spillways or outlet/downstream channels can result in drainage obstructions. Sloughing along embankment slopes should be closely inspected to ensure that underlying drainage layers are not exposed. Locations of surface sloughing should be recorded and the depth and extent of sloughing estimated.

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Soil Creep	Soil creep is a superficial expression of gradual, steady downhill movement of soils and loose rock on a slope. Surface expression of soil creep include low amplitude waves in superficial soil materials or leaning of trees away from the direction of movement. Although not serious in itself, signs of soil creep can forewarn potential slope stability problems which could affect the operation of adjacent spillway or outlet channels. Such conditions should be recorded and observed during subsequent field inspections.
Spalling	Concrete spalling and cracking is a common problem in concrete dams and concrete structures associated with an embankment dam. Spalling concrete (chipped, flaked or "pock marked") or cracks can lead to further deterioration of the structure over a period of time. Advanced stages of spalling can result in exposure of steel reinforcement to the weathering elements and further deteriorate the structural integrity of the dam. When observed, cracks or spalled sections should be repaired and patched to protect the structural integrity of concrete parts of the dam.
Surface Cracks	Movement, erosion, or settlement of the embankment materials can result in the superficial cracking of the embankment crest or slopes. Such cracks can develop on a singular basis or as a series of cracks radiating from a location of distress. Surface tension cracks are commonly found at the upslope head of a pronounced slope movement and cracking due to movement or slumping of materials downslope can be found near the toe of the embankment. The condition of observed surface cracks including width and depth of opening should be recorded and areal extent measured. The presence of surface cracks greater than 1" wide or a series of cracks in a concentrated area should prompt a Level III inspection to identify the cause of the embankment cracking and to assess the potential for dam instability due to the cracking.

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Surface Cracks (Continued)	Movement or settlement of a concrete dam structure can result in the superficial cracking of the crest or faces of the dam.
Surface Erosion	Surface erosion of an embankment can include erosion due to wave action, surface runoff, or traffic. Erosion due to traffic is primarily confined to the crest of the dam, where slope protection measures have been destroyed or displaced by passage of a vehicle and water is permitted to pond in the tracks. Vehicle tracks along the crest of the embankment should be examined for signs of intercepting surface cracks which serve as a conduit to drain water into the embankment. The continued erosive action of surface runoff can result in deep and multiple expressions of surface channels cutting into the crest and slopes of the embankment. Inspection for surface channels includes identifying the location of the channels and providing the depth, extent, and concentration of the channels eroded into the embankment. A Level III inspection should be performed to assess excessive erosion channels greater than 12" deep. Soil should be placed and compacted in developing surface channels and the surface seeded as part of routine maintenance work. Frequently used paths should be stabilized with stone aggregate or pavement.
Surface Rupture	Surface ruptures or shear zones can result from one or two dimensional movement of embankment or abutment materials during seismic or landslide events. Surface rupture can be observed in the form of a jagged or planar crack in an embankment, with one side of the crack vertically and/or horizontally displaced with respect to the other side, or as a scarp with observable vertical displacement. Shear zones can be observed in the form of slickensided, sheared or polished planes extending through the embankment or along the abutment. Permanent record of observations should be made of all existing occurrences as well as complete photographic documentation. Pre-construction investigations and/or construction records should be reviewed to determine if the condition existed within an abutment prior to dam construction. Observance of shear or rupture zones not recorded in earlier inspection documents should prompt an immediate Level III inspection to determine the cause of displacement and assess the stability of the dam.
Trash Racks	Trash racks located in the waterway at an intake structure can become clogged with debris and obstruct flow into the inlet. Debris collected along the concrete or steel bars of the trash rack should be removed as part of routine maintenance work.

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Undermining	Undermining conditions can occur beneath the floor of spillway aprons, chutes, control structures and stilling basins as a result of flowing water eroding and removing sediment or rock. Turbulent water conditions can result in undermining of the exit of outlet conduits and deep scouring of any unprotected stilling basin or downstream pool. When observed, the extent of undermining should be determined or best estimated, along with identification of the likely cause of undermining. Observation of existing conditions should prompt a Level III inspection and probable use of advanced test or inspection methods. Undermined sections should be grouted or concrete filled and protected against further erosion.
Unusual Movement at Toe of Slope	See slope stability.
Vegetation	Trees and brush should not be allowed to grow on the embankment dams, in emergency spillways or within approximately 20 feet of the embankment. Vegetation growth is permitted along riprapped slopes; however, such vegetation should be limited to grass and weeds and should not include any deep rooted plants. Vegetation should be thick, vigorous, and short enough to prevent clumping and laying over and to provide a clear view of embankment conditions. The development of deep rooted vegetation can create seepage paths into the interior of the embankment and cause stability problems. Periodic cutting/controlling of the embankment vegetation and adjacent areas is recommended as part of the routine maintenance program. Removal of trees or bushes from the embankment should be done only after consultation with the engineer in charge.
Whirlpool	The reservoir should be observed for whirlpools in the water located near the embankment structure. Such observations may indicate leakage of the reservoir through the embankment or abutment and should prompt further examination of the embankment, abutment and downstream channel environment for signs of unaccountable seepage. Investigation of observed whirlpool conditions may include the use of dye tests to track the path of water loss, or underwater inspections of the upstream embankment slope and/or reservoir bottom.

APPENDIX C

LIFE CYCLES

15 DAMS

15.01 EMBANKMENT DAMS

Embankment Dam and Appurtenant Works 50 YRS

Note: Life cycles should be re-evaluated for a particular dam site if one of the following conditions occur:

1) Significant changes in the state-of-the-art in design, analysis and construction since the structure was designed and built.

2) Upgrading of regulatory agency standards, or imposition of new standards where none previously existed.

3) Changes in the potential consequences of a dam failure to the downstream environment.

Source:
Engineering Foundation Conference, Safety of Small Dams, American Society of Civil Engineers 1974

15.02 CONCRETE DAMS

Concrete Dam and Appurtenant Works 50 YRS

Note: Life cycles should be re-evaluated for a particular dam site if one of the following conditions occur:

1) Significant changes in the state-of-the-art in design, analysis and construction since the structure was designed and built.

2) Upgrading of regulatory agency standards, or imposition of new standards where none previously existed.

3) Changes in the potential consequences of a dam failure to the downstream environment.

Source:
Engineering Foundation Conference, Safety of Small Dams, American Society of Civil Engineers, 1974.